Navya Nyāya for Scientists and Technologists : A first step

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Certificate

This is to certify that the thesis entitled

Navya Nyāya for Scientists and Technologists: A first step

is a report of work carried out under my supervision by Mrs. Amba P. Kulkarni, Roll no 9211101 and that has not been submitted elsewhere for a degree.

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Abstract

This thesis establishes a bridge between *Navya Nyāya* (NN) and Western logic - both at the level of representation as well as at the conceptual level. This bridge should serve as a platform on which the *naiyāyika* on the one hand and Western logicians, scientists, and technologists on the other hand can have a dialogue with each other.

A scheme for representing the NN expressions (NNE) diagramatically is presented. These diagrams are a modified version of Coceptual Graphs. Care has been taken to maintain isomorphism between the diagrams and the NNEs.

Three important conepts in NN – *abhāva* (negation), *nirūpaka* (describer), and *avacchedaka* (limitor) have been explained. Two of these concepts viz. *nirūpaka* and *avacchedaka* have no parallel in western logic. Though *abhāva* has a counterpart in the western logic, it differs from the concept of negation radically.

Resemblance of *samsarga vidhayā anugama* - a NN technique of abstraction with the concept of relation contraction has been demonstrated.

It is well known that NN does not make use of any quantifiers. An attempt has been made to answer the question – without using quantifiers how NN handles the quantification?

Dedicated to

my

parents-in-law

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Finally it is Achyut and Kedar who taught me what is patience.

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Contents

Chapter 1

Introduction

The words in any language are finite in number. The concepts they correspond to, however, form a continuum. Naturally the words - both content words as well as functional words - are going to be overloaded. This makes Natural Language ambiguous. In spite of that human beings do not find any difficulty in communication. This is mainly because of shared background knowledge. In case of unfamiliar situations, however, one cannot understand the other, unless there is a precision.

Different approaches are adopted to bring in precision, e.g. Western philosophers try to develop new formal languages. But these formal languages being artificial are inappropriate for general use. The other approach would be to identify the sources of ambiguity in natural languages and provide techniques to disambiguate them. The technical language of *Navya Nyāya* (NN) - An Indian system of logic, has been used by different Indian philosophical schools and other branches of study for bringing in precision.

The successfull application of *kāraka* theory to the processing of Indian laguages motivated us to look at NN for the disambiguation techniques without going into the philosophical details of that school.

NN has been studied very widely from philosophical point of view. But

our interest is not in the philosophical or historical aspects of the NN school. Can the concepts used therein be put to actual use? – This is the question, answer to which we are looking for. This thesis is the first step towards seeking an answer.

The purpose of this thesis is to establish a bridge between NN and Western logic. This bridge should serve as a platform on which the *naiyāyika* on the one hand and Western logicians, scientists, and technologists on the other hand can have a dialogue with each other.

The technique and the language of NN are known for their rigour. The very fact that these were used in almost all branches of studies in the Indian tradition, indicates their independence on the philosophical issues of that school.

In order to understand the NN system of logic, it is necessary to know

1. the conceptual methodologies adopted by that system, and
2. the techniques and the mode of presentation used by the system.

Unless one understands these two things, there cannot be any fruitful communication between the two diverse groups.

To understand the conceptual methodologies used by the NN system, the texts in NN should be accessible and there should be a communication between the NN scholar and a modern scientist/technologist. There are two different problems in communication.

1. **The language of communication:** Very few modern students know Sanskrit and very few traditional scholars know English. Moreover when it comes to technical matter, even a traditional scholar who knows English switches to Sanskrit and this is typically not convenient for a modern student. At the same time English brings in total change in the sentence structure. Hence if one wants to stick to English, one has to choose between intelligibility and the faithfulness to the (style of) original text. On the other hand, modern Indian languages have same sentence structure as that of Sanskrit, and hence use of any modern Indian language will assure both intelligibility as well as faithfulness to the original text. Therefore any modern Indian

language common to both will be more suitable for communication rather than English or Sanskrit. Moreover once the text on NN is available in any one Indian language, with the help of *anusāraka* - which produces the faithful image of the original text, one can access it in any other Indian language of one's choice.

2. **Mode of representation:** Another problem is that the present day scientists and technologists are trained in pictorial/symbolic representation. On the other hand the traditional scholars are trained in an oral tradition. Hence there is a necessity of common platform for exchange of ideas. Visual aids such as diagrams can be used as a common platform. While using diagrams it is necessary to maintain an isomorphism between these diagrams and the original expressions to prevent any loss of information.

This led us to device a scheme for representing the NN expressions (NNE) diagramatically. To have faithful representation of the expressions is itself not sufficient to understand the NN text. One should also know the concepts and techniques used in NN and should understand at least the motivation behind these concepts. Again these concepts are not many in number.

While discussing these concepts, we express them in terms of concepts in Western Logic that are 'similar' to these concepts. It should be borne in mind that this similarity should not be stretched further. It is always easy to introduce new things in terms of known ones. The similarities mentioned above should also be taken in this spirit.

Chapter 2 introduces the diagramatic representation for the NNEs. A notation 'similar' to that of Conceptual Graphs (CG) is used. This is followed by a step by step procedure to render any NNE into a corresponding diagram. The close resemblance of these diagrams with the corresponding CGs is also shown. Care has been taken to maintain isomorphism between the diagrams and the NNEs.

Chapter 3 introduces three of the important conepts in NN – *abhāva* (negation), *nirūpaka* (describer), and *avacchedaka* (limitor). Two of these concepts viz. *nirūpaka* and *avacchedaka* have no parallel in western logic. Though *abhāva* has a counterpart in the western logic, it differs from the concept of negation radically.

Chapter 4 presents one of the most widely used techniques in NN – *anugama*. Resemblance of *samsarga vidhayā anugama* with the concept of relational contraction in CG is also shown.

It is well known that NN does not make use of any quantifiers. The last chapter answers the question – without using quantifiers how it handles the quantification?

Chapter 2

Diagramatic representation of Navya Nyāya expressions

In this chapter we first introduce a scheme of representing the NNEs in terms of diagrams maintaining isomorphism between the two. In the next section we give a step by step procedure to transform any given NNE into a diagram.

2.1 Diagrammatic Representation

Diagrams are used to describe the cognitive structure *(jñāna akāra)* as well as the ontological structure *(sambaddha padārtha)*.
Diagrams consist of

1. rectangular nodes  which represent entities, and
2. circular nodes with arcs on both sides  which represent relations.

A relation in NN is always a relation of something(*pratiyogi*) in something(*anuyogi*). Since the status of two relata w.r.t. the relation between them being different, two different arcs are used to connect a relation to its relata.

These are

i) niṣṭha represented by ⟵

ii) nirūpita represented by ⟶⟶

For example, the cognition '*Dāśarathī Rāma*' gives rise to a cognitive structure that involves a relation *(putratva)* of *Daśaratha* in *Rāma*. This is represented as



Figure 1

This diagram can be read in different ways.
First we introduce the convention for reading the arrows.
The diagram



Figure 2

is read as

a niṣṭa R (in the reverse direction of arrow)

or

R vat a (along the arrow)

The diagram

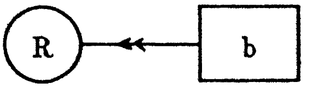


Figure 3

is read as

b *nirūpita* R (along the arrow)
(b se *nirūpita* R)

or

R *nirūpaka* b (in the reverse direction of arrow)
(R kā *nirūpaka* b)

With this convention, now the Figure 1 can be read in following different ways.

NE 1.1 *Daśaratha nirūpita putratva vān Rāma*
(Daśaratha se nirūpita putratva vālā Rāma)

NE 1.2 *Rāma niṣṭha putratva nirūpaka Daśaratha*
(Rāma niṣṭha putratva kā nirūpaka Daśaratha)

Remarks:

(1) Note the directions of the arrows. A relation will always have an incoming *nirūpita* arrow and outgoing *niṣṭha* arrow. This also puts a visual check on the diagram. Thus the following diagram is incorrect, which is also reflected in the wrong *nyāya* expression for it.



Figure 4 ⋆

NE 2.1 ⋆ *Rāma niṣṭha putrtva nirūpita Daśaratha*

(2) *tva* and *vat (vān)* are inverse operators, in the sense that they cancel each other. e.g. *putratvavān* = *putra*

(3) In natural language *nirūpita* gets replaced by *kā* in Hindi (or 's in English).

Thus NE 1.1 can be read as

Daśaratha kā putratvavān Rāma

i.e. *Daśaratha kā putra Rāma* or simply *Daśarathaputra Rāma*

Note : There is a difference in the traditional and modern conventions of relation. According to the Westerners R is the relation between x and y, if R of x is y. While for *naiyāyiks* R is the relation of x in y, if y has the property R described by x. Thus westerners represent '*Rām* is son of *Daśaratha*' as
son(Dasharath,Ram):



Figure 5

While *naiyāyiks* represent it as Figure 1.

Inverse Relation :

If R is the relation of x in y then R^{-1}, the inverse relation of R, will be the relation of y in x. Since the pratiyogi and anuyogi of the relation get interchanged, when the relation is replaced by its inverse relation, the *niṣṭha* and *nirūpita* arrows are also interchanged. The following diagrams make the point clear. For example, restricting ourselves to a universe consisting of males only, the inverse relation of *putratva* will be *pitṛtva*, i.e. if,



Figure 6

then

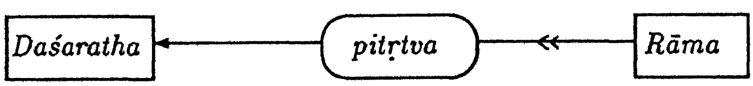


Figure 7

In this particular example, a special term (*pitṛtva*) for the inverse relation was available. But in general one need not have a separate term. In that case, we shall denote
R^{-1} by R-*nirūpakatva* or R^{-1} = R-*katva* in short.

For example, *ghata* is the *abhāvīya pratiyogi* (different from the term *pratiyogi* introduced earlier: see Appendix B) of *ghaṭābhāva*. Hence the relation of *ghaṭābhāva* in *ghaṭa* is *pratiyogitā*.

This is represented as

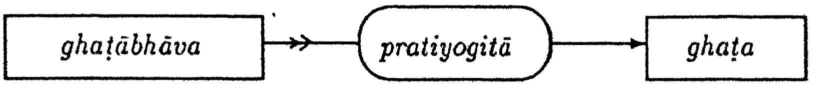


Figure 8

The corresponding NNE is
NE : *ghaṭābhāva nirūpita pratiyogitā vān ghaṭa*
Now the relation of *ghaṭa* in *ghaṭābhāva* will be *pratiyogitākatva*. This is represented as

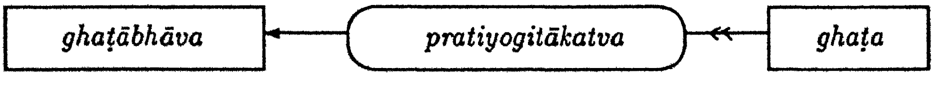


Figure 9

NE : *ghaṭa nirūpita pratiyogikatvavān ghaṭābhāva*
or simply as
ghaṭa nirūpita pratiyogitā nirūpaka ghaṭābhāva
or using *bahuvrīhi samāsa as ghaṭa pratiyogika ghaṭābhāva.*

Now let us see the representations of a few commonly used relations in NN. Here we have introduced some abbreviations for certain relations that appear very frequently in the NN texts. The aim here is not to explain these concepts but just to have a faithful representation of the concepts or terms that are used. Hence only the linguistic aspects viz. compound formation or formation of cliches are considered and they are given the proper diagrammatic representation.

2.1.1 *avacchinnatā*

A relation which is frequently used in NN is *avacchinnatā*.
This is represented by

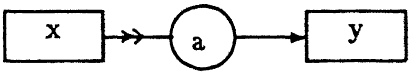


Figure 10

or in compact form as



Figure 11

e.g.

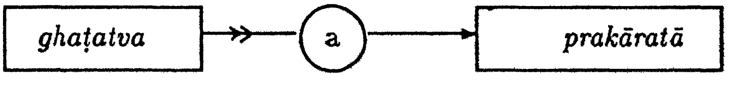


Figure 12

This is read as
NE: *ghaṭatva nirūpita avacchinnatāvati prakāratā.*
or more compactly as
ghaṭatvāvacchina prakāratā.

2.1.2 *pratiyogitā (abhāviya)*

As already seen earlier, *Ghata* is the (*abhāviya*) *pratiyogi* of *ghaṭābhāva*.
The *(abhāviya) pratiyogitā* of *ghaṭābhāva*, therefore, resides in *ghaṭa*.
This fact is represented diagrammatically with P as abbreviation for *pratiyogitā* as

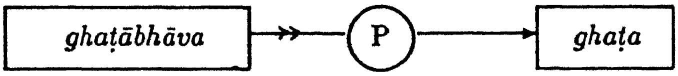


Figure 13

and can be read as
NE: *Ghatābhāva nirūpita pratiyogitāvān ghaṭah.*
Now the diagrammatic representation of
ghaṭatvāvacchinna ghaṭa niṣṭha pratiyogitā nirūpaka abhāva
will be

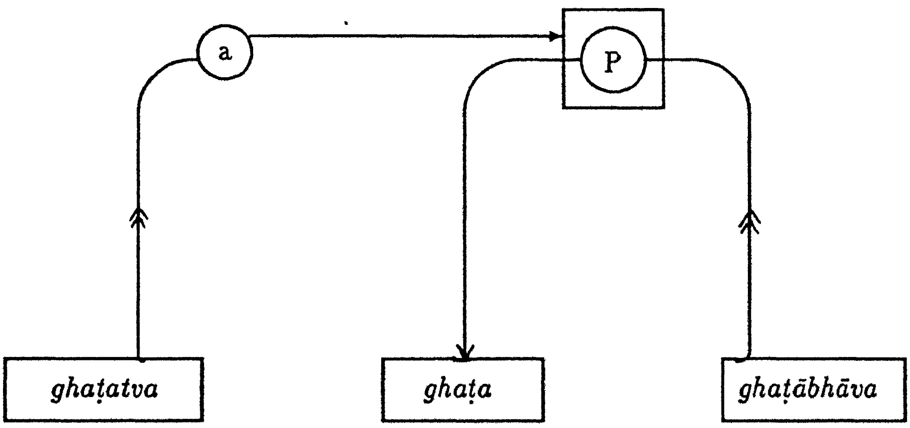


Figure 14

Note here that *pratiyogitā* which is an entity is also manifested as a relation.

2.1.3 *nirūpyatā*

This is represented by

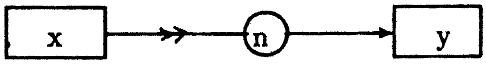


Figure 15

e.g.

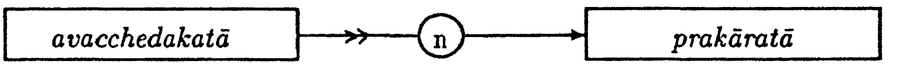


Figure 16

This can be read as

avacchedakatā nirūpita nirūpyatāvati prakāratā,

or in short

NE: *avacchedakatā nirūpita prakāratā*
(avacchedakatā se nirūpita prakāratā)

Since the *nirūpita* arrow itself can serve as a relation of *avacchedakatā* in *prakāratā*, the above diagram can be drawn more compactly as

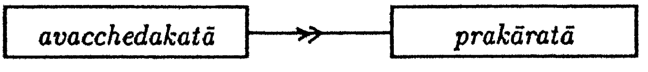


Figure 17

2.1.4 *niṣṭhatā*

When two entities have *ādhāra - ādheya bhāva* between them, *ādheya* is said to reside *(niṣṭha)* in the *ādhāra*. *ādheya* will be then said to have *niṣṭhatā* [1] in it.
For example *viṣayatā* resides in *viṣaya*.
Therefore *viṣayatā* is the *ādheya* of *viṣaya*. Hence *ādheyatā* is in *viṣayatā*

[1] also known as *vṛttitā* or *adheyatā*

which is *nirūpita* by *viṣaya.* This is represented diagramatically as

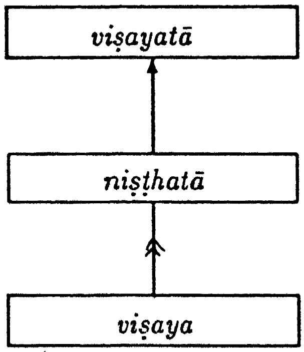


Figure 18

The corresponding *nyāya* expression for this will be
NE *viṣaya nirupita niṣṭhatā vati viṣayatā.*
(viṣaya se nirupita niṣthatā vālī visayatā.)
or in short *viṣaya niṣṭha viṣayatā.*
Since, *niṣṭha* arrow can itself serve as an abbreviation, we can draw it as

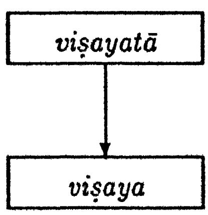


Figure 19

2.1.5 *abhinna*

If two entites x and y are ontologically identical,
the identity *(tādātmya)* relation between them, is represented by

$$\boxed{x} \equiv \boxed{y}$$

e.g.

NE *ghaṭaniṣṭha viśaṣyatā abhinna prakāratā*
will be represented as

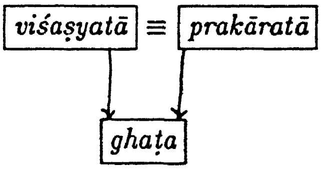


Figure 20

2.1.6 *paryāpti*

ghaṭa paṭa niṣṭha dvitva is related with *ghaṭa* and *paṭa* by the relation of *paryāpti.*

This is represented as

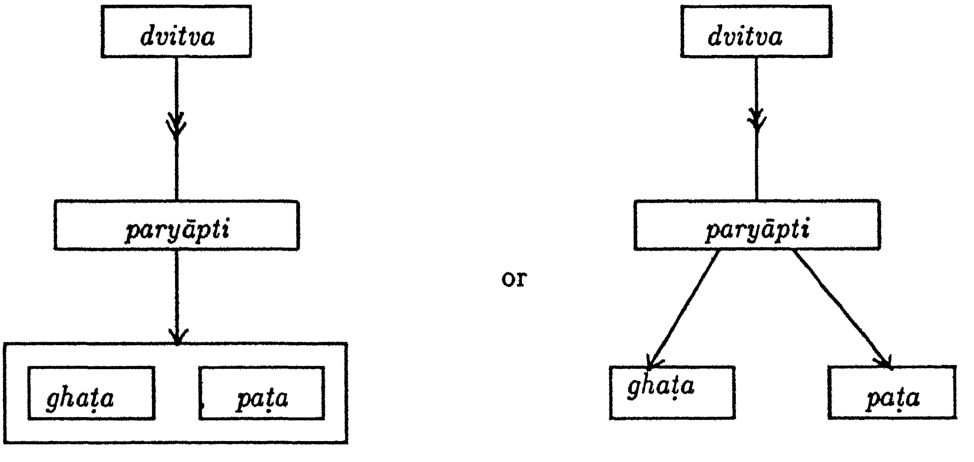


Figure 21

This can be read as
NE *dvitva nirūpita paryāpti āśrayau ghaṭapaṭau*
(dvitva se nirūpita paryāpti ke āśraya ghaṭa aura paṭa hai)

2.2 Procedure for Transformation of NNE to diagrams

With the help of examples, we now show how a NNE can be transformed by a step by step procedure to the diagrams. We also show the corresponding conceptual graphs and the close resemblance of these diagrams to the CGs.

Example 1

Consider the sentence:

Mohanāya Rāmah pustakam dadāti.

(to Mohan Ram book gives)

Naiyayikas represent the *śābdabodha* of this sentence as

NE: *Mohana uddeśyaka pustaka karmaka dāna anukūla kṛtimān Rāmah*

Such an expression becomes ambiguous for the following two reasons.

1. Sanskrit is very rich in compound formation.

   For example, the word *rāmeśvara* is ambiguous between

   Rāma hai īśvara jisake vaha

   and *Rāma ke īśvara.*

2. Because of linear representation, unless one knows the context, it is difficult to determine the *viśeṣaṇa - viśeṣya.*

For example, the phrase 'light red car' is ambiguous between

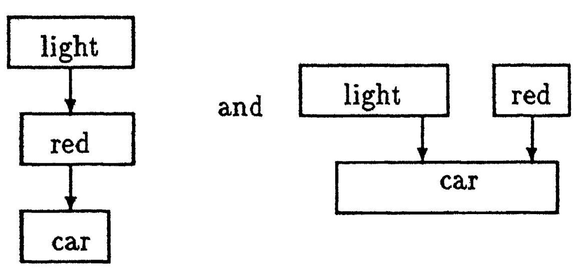


Figure 22

After resolving the above ambiguities, if any, we represent the above NNE diagrammatically as

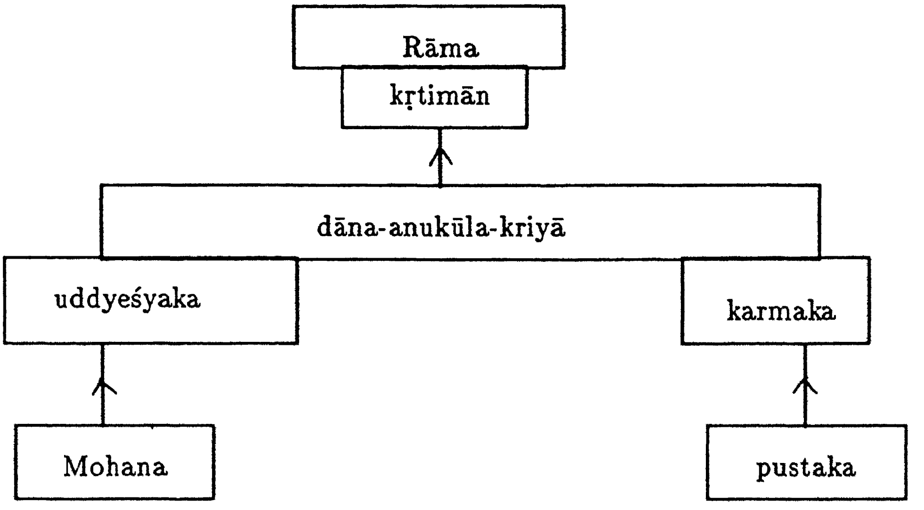


Figure 23a

Here arrows indicate the direction along which diagram is read. The small boxes attached to big boxes stand for adjectives of the contents in the big boxes. Thus in the above figure, *dāna-anukūla-kriyā* has two adjectives, viz. Mohana *uddeśya hai jisakā* and *pustaka karma hai jisakī*.
Another way of representing this is

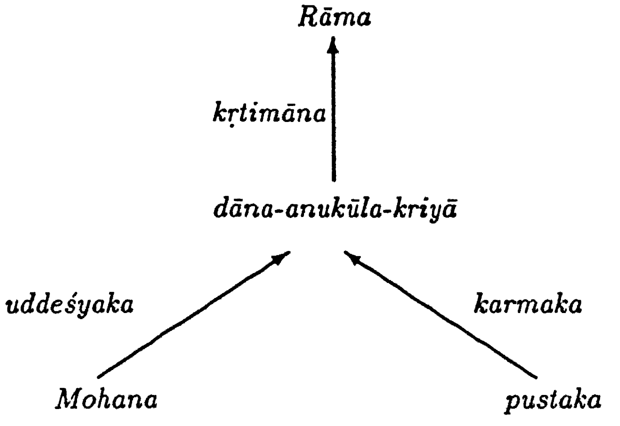


Figure 23b

The above diagram therefore can be read as
Mohana uddeśyaka (uddeśya hai jisakā) aura pustaka karmaka (karma hai jisakī aisī) dāna anukūla kriyā kā kṛtimān (kartṛtvavān) Rāma hai.

Further the above diagram can be represented as follows, stating explicitly the relations between different terms.

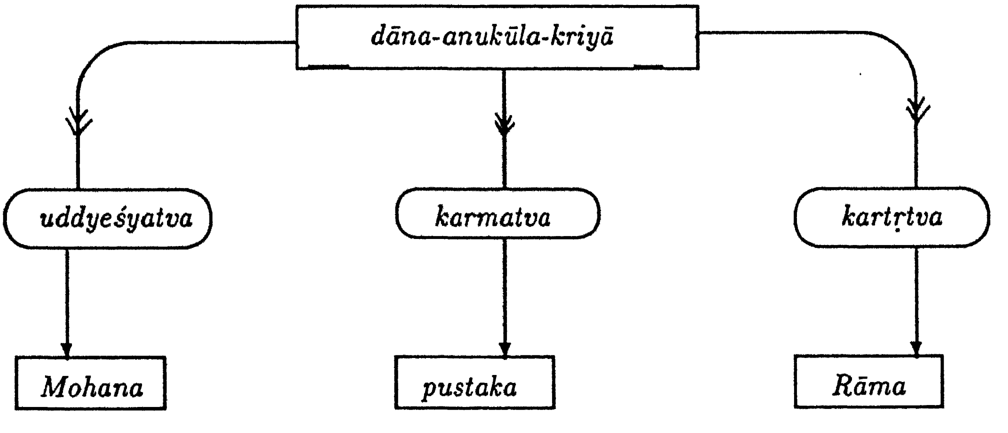


Figure 24

This is similar to the following Conceptual Graph for the above sentence.
This graph is read as
Mohan is uddeśya of dāna-anukūla-kriyā,

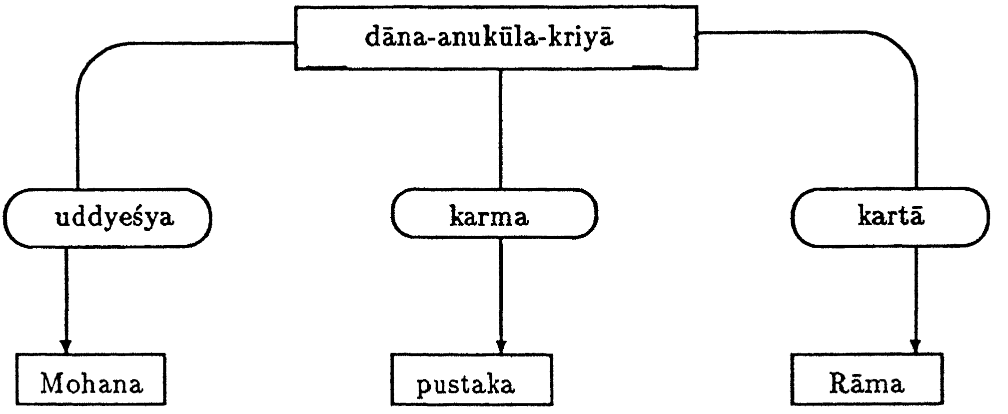


Figure 25

pustaka is karma of dāna-anukūla-kriyā,
and *Rāma* is *kartā* of *dāna-anukūla-kriyā*.

Example 2:
Now let us see the following definition of *vyāpti*. This definition is the result of few insertions in the *pratham vyāpti lakṣaṇa*, given by mathurānātha [Shukla,1984].

vyāpti : sādhyatā avacchedaka sambandhāvacchinna sādhyatā avacchedakāvacchinna pratiyogitā nirūpaka abhāvavat adhikaraṇa niṣṭha adhikaraṇatva nirūpita hetutā avacchedaka sambandhāvacchinna vṛtitva pratiyogika sāmānya abhāva hetau

A modern scholar finds it very difficult to read such expressions and understand them. Hence, it is necessary to parse this sentence first. To obtain a parse one should have a domain and language knowledge as stated above.

Below is a modifier-modified tree for the above sentence, that is obtained after resolving the ambiguities, if any, showing the *viśeṣya-viśeṣaṇa bhāva* (modifier-modified relations) among different terms[see Figure 26]

Here the label on each arrow indicates the relation of the term at the root of the arrow with the term at the head of the arrow.

Thus e.g. the relation of *pratiyogitā* in *abhāva* is *nirūpaka.*
If an arrow does not have a label then the term at the root of the arrow is just a qualifier *(viśeṣaṇa)* of the term at the head of the arrow.
Thus in the above figure '*sāmānya*' is a qualifier of '*abhāva*'.

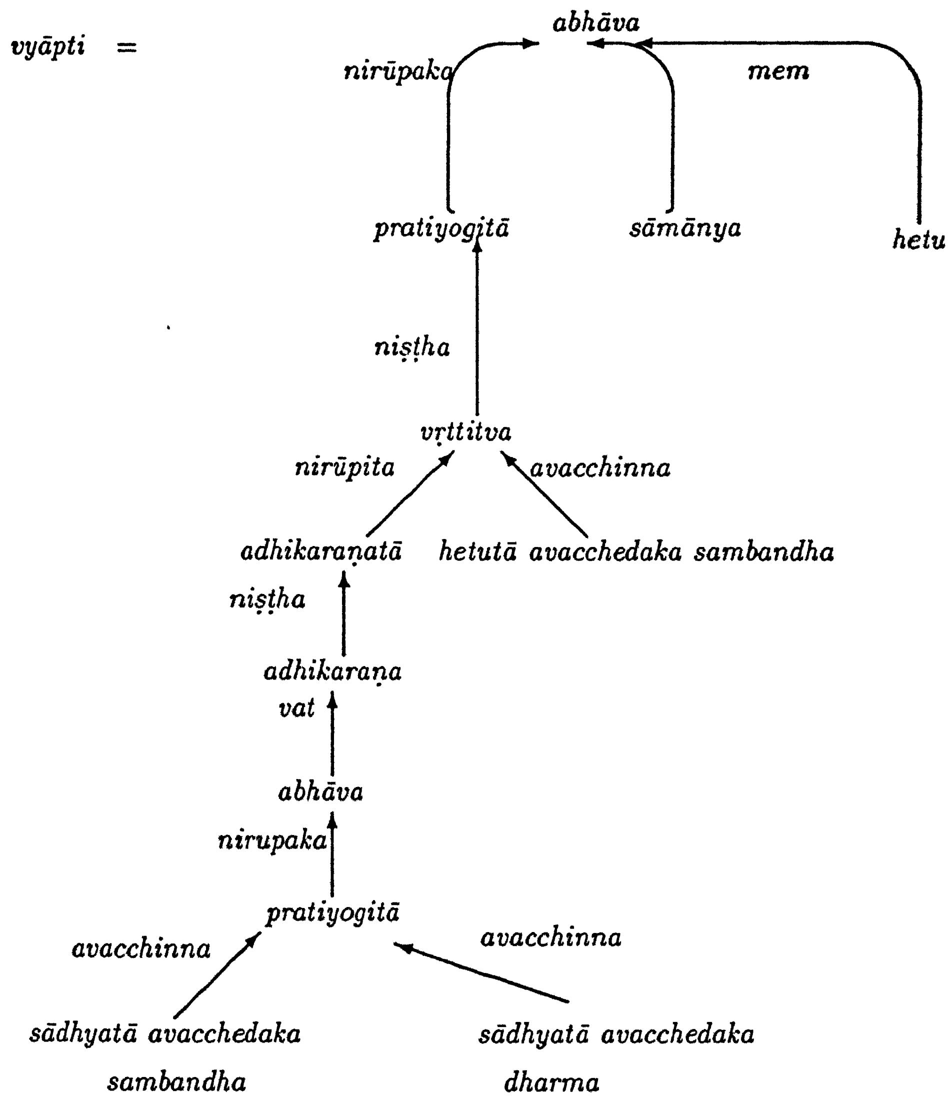

vyāpti =
abhāva
nirūpaka
mem
pratiyogitā
sāmānya
hetu
niṣṭha
vṛttitva
nirūpita
avacchinna
adhikaraṇatā
hetutā avacchedaka sambandha
niṣṭha
adhikaraṇa
vat
abhāva
nirupaka
pratiyogitā
avacchinna
avacchinna
sādhyatā avacchedaka
sambandha
sādhyatā avacchedaka
dharma

Figure 26

Now using the conventions given earlier for diagrammatic representation, the modifier-modified tree can be easily converted to the following diagram. Aim here is just to obtain a faithful image of the given NNE, and as such no attempt has been made to explain it. The next two chapters discuss the concepts and techniques involved in NN.

vyāpti =

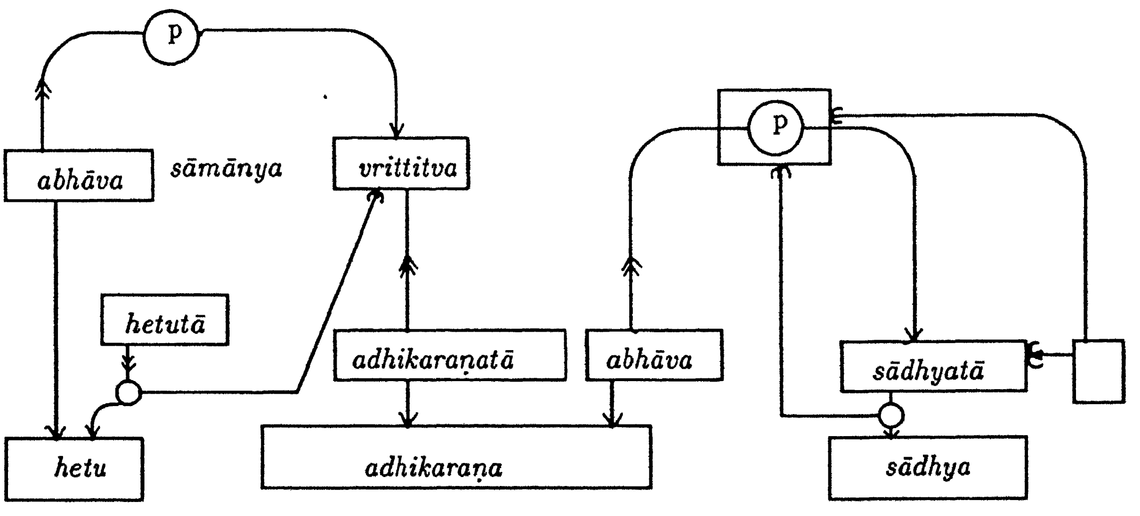


Figure 27

2.3 summary

The notation introduced for representing NNEs is based on CG. However there are subtle differences between the two systems at conceptual level. For *naiyāiks* relation is a property residing in its *anuyogi.* Hence in the same cognition, an entity may also get manifested as a relation and vice versa. All the relations except *paryāpti*, are diadic. These differences get reflected in the diagrams.

Chapter 3

Coneptual methodologies in Navya Nyāya

In this chapter three important concepts in NN viz.- *abhāva*, *nirūpaka* and *avacchedaka* are discussed. In the first section the difference between the concept of *abhāva* and that of negation in western logic is highlighted. This section also introduces two different types of *abhāvas* used in NN. Second section explains the concept of *nirūpaka* with the help of example. Finally the most important and widely used concept in NN – *avacchedaka* is the topic of last section. Here three different senses of *avacchedaka* are discussed. It has been also pointed out that the underlying concept behind these three seemingly different senses is same.

3.1 *abhāva*

The sentence 'man is mortal' is ambiguous between two readings

- some man is mortal
- every man is mortal

The Conceptual Graph (CG) for this sentence is

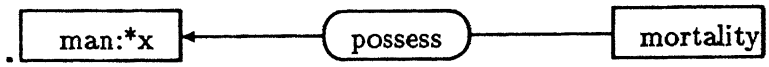


Figure 1

This is a weak graph having both the readings. The conceptual graph corresponding to the strong reading viz. 'every man is mortal', will be

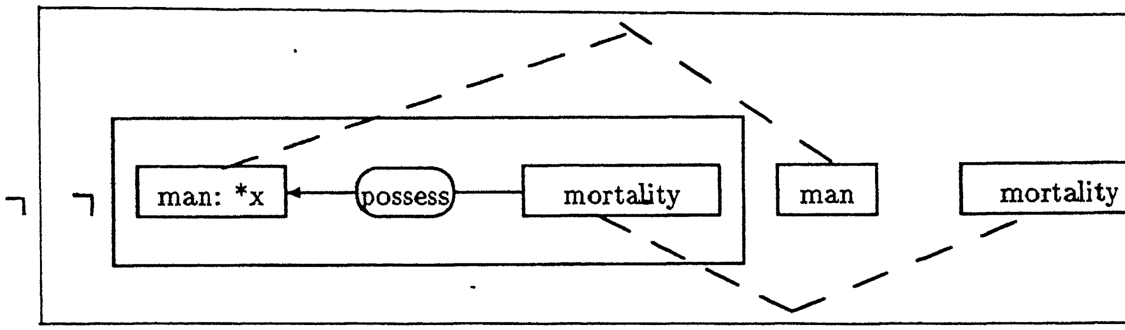
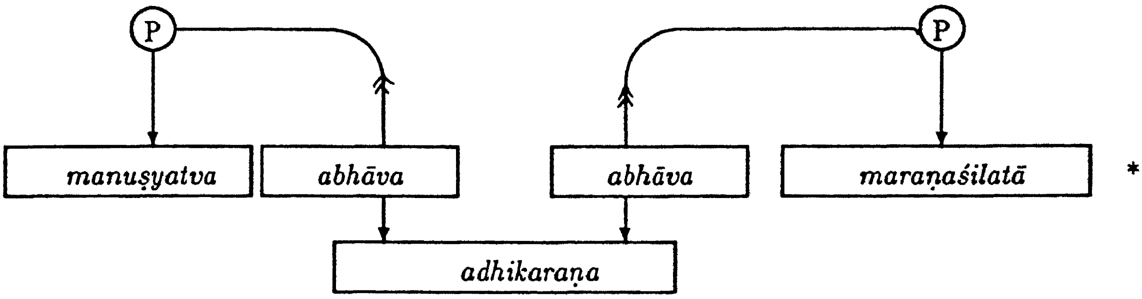


Figure 2

In NN also, the sentences with universal quantifiers, like the one given above, are expressed by using the notion of negation.
A *naiyāyika* will say,
'Humanity is absent from a locus, in which there is absence of mortality' [Matilal,1968;p3]
The diagramatic representation of this will be



(* indicates the starting point for reading the diagram.)

Figure 3

There is vast difference between the concept of negation in western logic and concept of *abhāva* in *nyāya*. In *nyāya* there are two major types of absences, corresponding to the canonical forms

'a has no b' (*atyanta abhāva*)[1]

and

'a is not b' (*anyonya abhāva*[2])

3.1.1 *atyanta abhāva*

nyāya allows only term negations whereas in western logic, it is the proposition that is negated. The difference will become clear with the following example.

The Conceptual Graph for the sentence
The table does not have any book on it
is

[1]This being used more frequently than the other one, is many times referred to as *abhāva*

[2]This is also called *bheda - bhinnatāvālā*

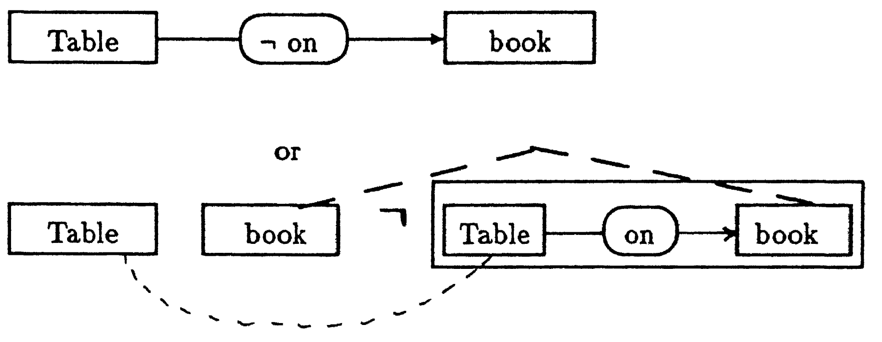


Figure 4a

Since in *nyāya*, the canonical form is 'a has b', *naiyāyika* expresses the above fact as

ṭebala has book-*abhāva.*

Hence the diagramatic representation will be

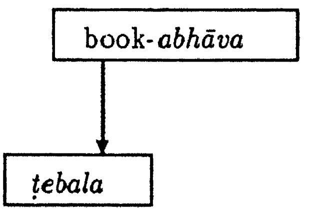


Figure 4b

This representation is, however, silent on whether it is the absence of one particular book or of all books. To indicate the quantity, NN makes use of a technical term called *avacchedaka* which we will be discussing in the following section.

The term *'abhāva'* is incomplete in itself. One cannot just say,

ṭebala has *abhāva*

It has an expectancy - *abhāva* of what? This object, whose *abhāva* is being referred to, is called the *pratiyogi* of the abhāva. Hence the book *abhāva*, is referred to as book *pratiyogika abhāva*,

i.e, the *abhāva* whose *pratiyogi* is book.

Diagramatically, this is represented as

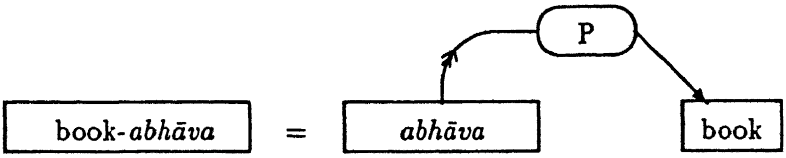


Figure 5

Hence, Figure 4b becomes

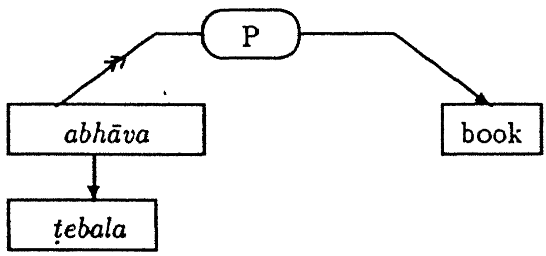


Figure 6

3.1.2 *anyonya abhāva*

If a and b are two different objects, then one has the *bheda* (difference) of the other.
Diagramatically, difference of a in b is represented as

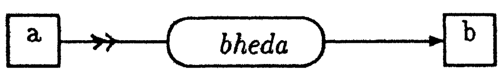


Figure 7

NE 'a' *nirūpita bhedavān* 'b'
('a' *kā bheda* 'b' *mem*)

Since *bheda* means *bhinnatāvat* (i.e., the one which posesses difference), it has an expectancy - difference of what? This object whose difference (absence) is referred to will be, as stated earlier, called a *pratiyogi* of *bheda*. In

the given situation 'a' is the *pratiyogi* of the *bheda*. Hence 'a' has *pratiyogitā* of *bheda*.
Therefore, by expanding 'a *kā bheda*' as 'a *niṣṭha pratiyogitā nirūpaka bheda*', the above figure becomes

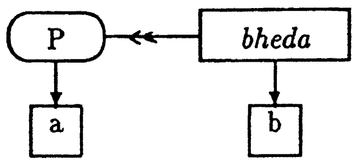


Figure 8

If a and b were not different, then there would have been an identity relation (*tādātmaya sambandha*) between the two. Therefore, the *pratiyogitā* in a is said to be *avacchinna* (limited by) by *tādātmaya sambandha*.

If b has *bheda* of a, then it is a-ness which is absent in b,
Hence one can also write,

'b has *bheda* of a'

as

'b has an (*atyanta abhāva*) absence of a-ness.'

Thus diagramatically.

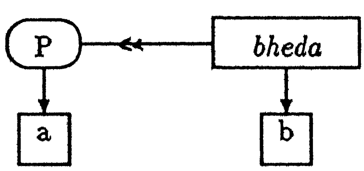


Figure 9

is equivalent to

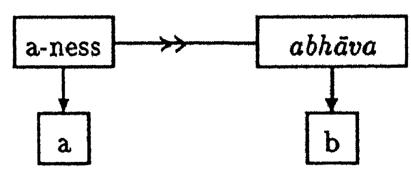


Figure 10

Fig 10 can further be expanded as

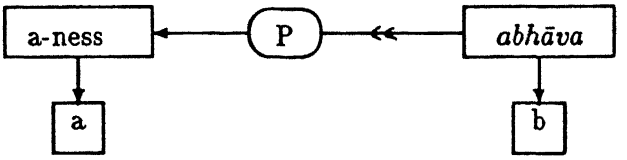


Figure 11

The *pratiyogitā* P in Figure 11, is said to be *avicchinna* by *samavāya sambandha* (inherence relation)[3]

Figure 8 and Figure 11 differ only in the *pratiyogis* of the *abhāva*. In case of *bheda* the *pratiyogi* is a and in case of *atyanta abhāva* the *pratiyogi* is a-ness. Ingalls has seemed to have missed this point.(See Appendix A)

Thus the fact that 'a is different from b' can be viewed in two different ways.

b has difference of a (see Figure 8)

or

b has absence of a-ness (see Figure 11)

3.2 *nirūpakatā*

Whenever there is expectancy for other object in the knowledge of one, these two objects are said to have *nirūpya-nirūpaka bhāva* between them.

For example, the word *khā* (to eat) has an expectancy for two objects - viz. *kartā* (agent) and the *karma* (theme), of the eating activity. Hence the activity of eating *khā* and the *kartā* (or *karma*) have *nirūpya-nirūpaka bhāva* between them.

The one which describes (*nirūpaṇa-karanevālā*) the other is called a *nirūpaka*, and the one which is being described is called a *nirūpya*.

[3]If b were same as a, a-ness would have been inhered in b, or a-ness would have been related to b by the *samavāya* (inherence) relation.

Thus, when one says

Rāma khā rahā hai.

(Ram is eating),

immediate reaction is what is he eating?

Thus, the patient of the activity of eating, say mango, will describe the activity of Ram's eating. Hence, mango, or the *karma* in this case is the describer (*nirūpaka*) and the activity (kriyā) *khā* is being described (*nirūpya*).

Diagramatically,

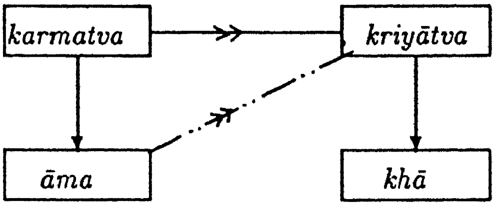


Figure 12

This figure can be read in following different ways

āma niṣṭha karmatva nirūpita kriyā khā

or

āma nirūpita kriyātvavān khā

or

āma nirūpita kriyā khā

Similarly when one says, *āma* is the *karma*, the natural question is *karma* of which activity. Thus an activity describes the *karma*. Or *karma* gets described by the *kriyā*.

Diagramatically

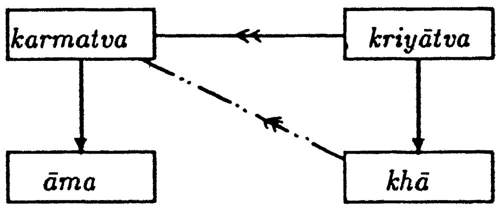


Figure 13

khā kriyā nirūpita karmatvavān āma

or

khā kriyā niṣṭha kriyātva nirūpita karmatvavān āma

or

āma niṣṭha karmatva kī nirūpaka kriyā khā

The last sentence can also be read in short-cut as

āma niṣṭha karmatvaka khā

kartṛtva and *kriyā* describe and are described by each other. Hence they also have *nirūpya-nirūpaka-bhāva.*

The properties in *nirūpya* and *nirūpaka* are *nirūpyatā* and *nirūpakatā* respectively.

Few other examples of pairs having *nirūpya-nirūpaka-bhāva* are

- *ādhāratā-ādheyatā*
- *anuyogitā-pratiyogitā*
- *avacchedakatā-avacchinnatā*
- *nirūpakatā-nirūpyatā*

The *nirūpyatā* or *nirūpakatā* in that sense is a very general relation. It just says, by some relation, the two objects are related. The natural language counterpart of the *nirūpaka* is the word denoting possession. ("*kā*" in Hindi or " 's" in English).

The expression

Daśaratha ke putra

may be expressed in First order predicate calculus (FOPC) as

α x father(Dasharath,x)

which corresponds to x satisfying the above predicate. Thus value of x depends on the first argument of the predicate father, viz. Dasharath in this case.
In NN the corresponding expression and its diagrammatic representation will be

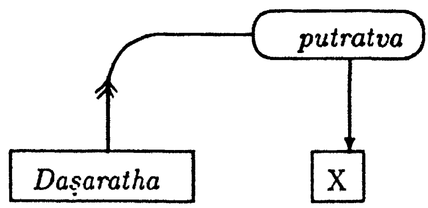


Figure 14

NE: *Daśaratha nirūpita putratva vān*

Thus the value of x gets determined by the *nirūpaka* of *putratva* viz. *Daśaratha* in this case.

3.3 *avacchedaka*

The *avacchedaka* is one of the very key concepts in *nyāya.* It is used very widely, and extensively and in many different senses.
Three of the senses are

- as a mode of cognition[Bhattacharya,1990a;p134]
- as a quantifier[Bhattacharya,1990a;p137,Stall,1988;p83]
- as a *ṣakyatā avacchedaka*[Guha,1979;p18]

First we will explain these three senses of *avacchedaka* with the help of examples. Next we will show how these seemingly unrelated senses have a common underlying concept.

3.3.1 Mode of cognition

When one looks at a blue pen, one may perceive it in many different ways. E.g.

```
- as a blue pen
- as a coloured pen
- as a blue substance, etc.
(depending on ones intentions).
```

Though ontologically same object is involved in all the three cognitions, it is the mode of cognition which differentiates one from the other. Ontologically, the pen has pen-ness, blue colour and substance-ness in it, and the blue colour has blue-colourness.

Digramatically

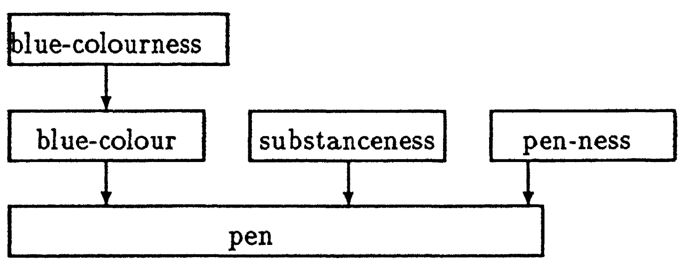


Figure 15

Now it is the intention which focuses on only some part of the figure and ignores the rest. E.g. when one cognises the blue pen as a blue pen, the cognition can be represented as

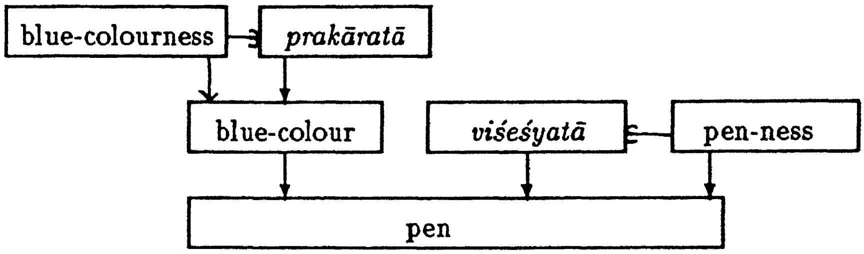


Figure 16

In all the three cognition, pen is the *viśeṣya* (qualificand) and blue-colour is the *prakāra* (*viśeṣaṇa* roughly).
It is the *avacchedaka* which distinguishes one cognition from the other. This cognition has pen-ness as the *avacchedaka* of *viśeṣyatā* and blue-colourness as the *avacchedaka* of *prakāratā*. This simply means that a pen is cognised only as far as it has pen-ness and blue-colour in it, i.e. as far as a writing device say and no other property (such as thick or thin, whether it writes smoothly or not, etc.) in it is being considered.
Thus this *avacchedaka* serves as a mode of cognition.
Similarly by taking different combinations of *avacchedaka* for *prakāratā* and *viśeṣayatā* one gets different cognitions.
Thus the ontologically identical things may have different cognised structures or in other words, objects may be cognised through different modes.

This use of *avacchedaka* (limitor) therefore removes the problem of 'referential opacity' . Though *kālidāsa* is the author of both *ṣākumtala* as well as *meghadūta*, the sentence

ṣākumtala kā racayitā meghadūta kā racayitā hai

is not vacuous, saying *kālidāsa* is *kālidāsa*. The cognition arising from this sentence in NN terminlogy can be represented as

(see figure on next page)

(* : denotes the starting point for reading the diagram).
NE: *ṣākumtala niṣṭha janyatā se nirūpita janaka niṣṭha adhikaraṇatā meghadūta niṣṭha janyatā se nirūpita janakatā se avacchinna hai.*

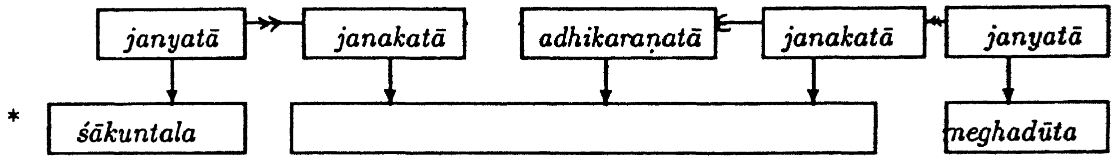


Figure 17

3.3.2 Quantifier

According to NN theory every object always has some relation with the other objects involved in the cognition. This imposes some 'role' on every object with the other one. E.g. a person can be a father for his son, a teacher for his students and a husband for his wife . Hence he will have the abstract properties viz. father-ness, teacher-ness, and husband-ness in him.

The *avacchedakas* of such abstract properties serve the purpose of universal quantifiers.
We explain this use of *avacchedaka* with the help of two examples.
Example1:
The sentence

manuṣya buddhimāna hai ——(1)

is ambiguous between two readings

koī eka manuṣya buddhimāna hai.

and

sabhī manuṣya buddhimāna hai.

In the sentence (1) *manuṣya* is the *uddeśya*. *uddeśyatā* is the abstract property in *uddeśya*, and the *uddeśyatā avacchedaka* is *manuṣyatva*.

Diagramatically, it is represented as Figure 18.

Now the question of disambiguating boils down to specifying the relation between the two terms - *manuṣyatva* and *buddhimattā*

If αx R(x) denotes a restricted variable x such that R(x),[Helperin,1957,Stall,1988;p83] then *buddhimāna manuṣya* can be represented as

αx has (x, *buddhimattā*) $\wedge$ *manuṣya* (x)

This expression itself does not indicate whether x is an existential or univer-

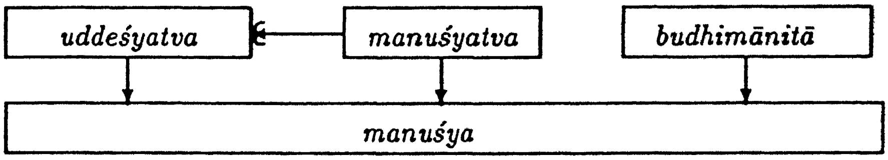


Figure 18

sal. It is the quantifier viz. $\exists$ or $\forall$ which further quantifies the expression.
Thus
$\exists\alpha$ x has (x, *buddhimattā*) $\wedge$ *manuṣya* (x)
denotes

koī eka manuṣya buddhimāna hai

and
$\forall\alpha$x has (x, buddhimattā) $\wedge$ *manuṣya* (x)
denotes

sabhī manuṣya buddhimāna haim.

In *nyāya*, *naiyāyika* states the relation R of *manuṣyatva* in *buddhimattā* as

sāmānādhikaraṇya and *avacchinnatā*

in case of existential and universal quantifiers respectively. [Matilal,1968;p78]

Thus using NN terminology,
if *uddeśyatva avacchedaka* (viz.*manuṣyatva*) *ke sātha buddhimattā kā sāmānādhikara*
hai,
then, the cognition discribed by these words corresponds to

koī eka manuṣya buddhimāna hai

while the cognition described by
uddeśyatva kā avacchedaka (viz. *manuṣyatva*) *buddhimattā se vyāpya hai*
corresponds to the sentence

sabhī manuṣya buddhimāna haim.

Thus it is the *avacchedaka* of the abstract property that serves as a universal quantifier.
Diagramatically, (See Figure 19)

If
R is *sāmānādhikaraṇya* then the above diagram reads,

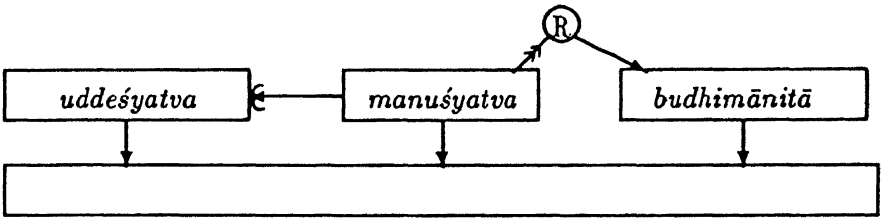


Figure 19

koī eka manuṣya buddhimāna hai.
and if R is *avacchinnatā* (the abstract property residing in one which gets limited) then the above diagram reads
sabhī manuṣya buddhimāna haim.

Let us see how the relation *avacchinnatā* gives the semantics of universal quantifier. When we say the relation R is *avacchinnatā*, it means *buddhimattā* is *avacchinna* by *manuṣyatva.* By this we understand the locus of *buddhimattā* is one who has *manuṣyatva* and no other property other than *manuṣyatva* is being considered while stating *manuṣya buddhimāna hai.*

Thus effectively it says, it is an arbitrary man (*sāmānya manuṣya*) who is intelligent.

In other words this statement is about an arbitrary man and hence is applicable to every man in particular. This brings in the universal quantifier in picture. When the relation R is *sāmānādhikaraṇya*, then it just says that the two properties *manuṣyatva* and *buddhimattā* co-exist.

Example 2:
Here we analyse two of the insertions, resulting in the improvement of the definition of *vyāpti*, that are discussed in the *pūrvapakśavyāpti nirūpaṇam* of *anumāna khaṇda* of the *siddhānta muktāvalī*[4][Joshi,1985;p132]

vyāpti (pervasion) is the relation of pervader (*vyāpaka*) in pervaded (*vyāpya*). Since the definition of *vyāpti* in NN literature is discused in the context of

[4] *siddhānta muktāvalī* is the commentory by *viṣvanāthapañcānana bhattācārya* on his own work *bhāśā pariccheda.*

inference, the pervader is *sādhya* and the one which is pervaded is ***hetu.***

The definition given by *viśvanātha* is
vyāpti : sādhyavat anya avṛttitvam hetau
First we rewrite this in Hindi, making use of linguistic knowledge

= *sādhyavat anya avṛttitva hetu mem*

= *sādhyavāle (adhikaraṇa) se bhinna (adhikaraṇa) se nirūpita vṛttitā kā abhāva hetu mem*

= *sādhyavāle (adhikaraṇa) ke bhedavāle (adhikaraṇa) se nirūpita ādheyatā kā abhāva hetu mem*

= *sādhyavāle (adhikaraṇa) mem niṣṭha pratiyogitā nirūpaka jo bheda, aise bhedavāle (adhikaraṇa) se nirūpita ādheyatā niṣṭha pratiyogitā nirūpaka abhāva hetu mem.*

[*sādhya ke adhikarana se bhinna adhikaraṇa mem na rahanāpana kā abhāva (hetu mem) hī vyāpti hai.*]

Now we represent this diagramatically as

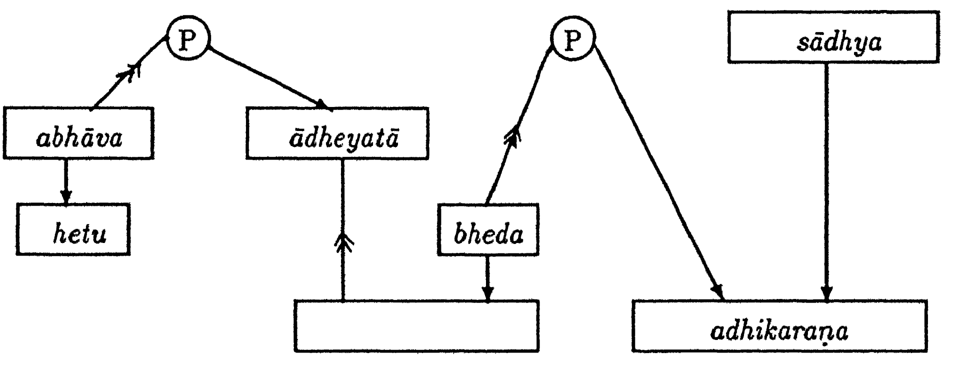


Figure 20

From this definition, it is not clear

1. Whether the difference *(bheda)* is to be taken of one particular loci of *sādhya* or with all loci of *sādhya.*

2. Whether *hetu* should be absent in one such different locus that is different from the locus of *sādhya* or all loci that are different from the locus of *sādhya.*

It is quite clear from the term *'vyāpti'* that in both cases, we should consider all loci. Thus the difference *(bheda)* is to be taken from all loci of *sādhya* and *hetu* should also be absent from all loci that are different from the locus of *sādhya*. Let us see how this is achieved in NN technical language. *viśvanātha* gives two insertions corresponding to these two.
The phrase *sādhyavat anya* or *sādhyavāle (adhikaraṇa mem) niṣṭha pratiyogitā nirūpaka bheda*
is explained as *sādhyavāle (adhikaraṇa mem) niṣṭha sādhyavatva se avicchinna, pratiyogitā nirūpaka bheda.*
This insertion, states that the *pratiyogitā* of the *bheda* in the *sādhya-adhikaraṇa* is limited by *sādhyavattva.*
Similarly the phrase *avṛttitva*
or
ādheyatā niṣṭha pratiyogitā nirūpaka abhāva
is explained as
ādheyatā niṣṭha, ādheyatātva se avacchinna, pratiyogitā nirūpaka abhāva
This insertion says that the *ādheyatā niṣṭha pratiyogitā* is limited by the *ādheyatātva.*

With these two insertions, the modified definition of *vyāpti* will be *sādhyavāle (adhikaraṇa) mem niṣṭha, sādhyavatva se avacchinna, pratiyogitā, nirūpaka, jo bheda aise bhedavāle (adhikaraṇa) se nirūpita, ādheyatā niṣṭha, ādheyatātva se avicchinna, pratiyogitā nirūpaka abhāva hetu mem hai.*
Diagramatically,

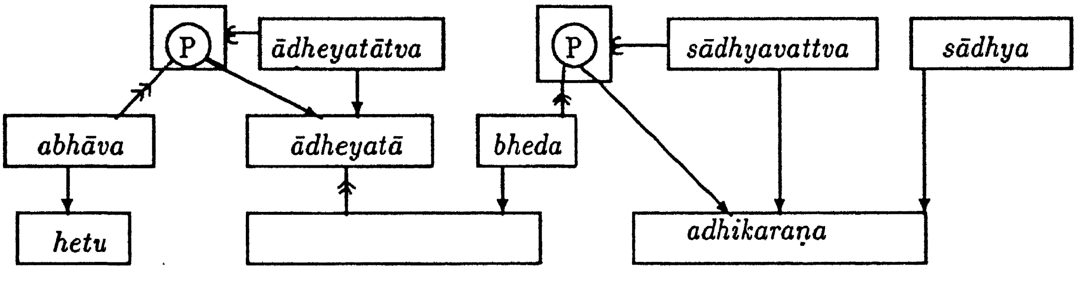


Figure 21

3.3.3 To denote a *sāmānya* object

According to *nyāya pada* (word) and *padārtha* (its meaning) are related with each other by a relation. The relation of *pada* in *padārtha* is called *śakti.*



e.g.

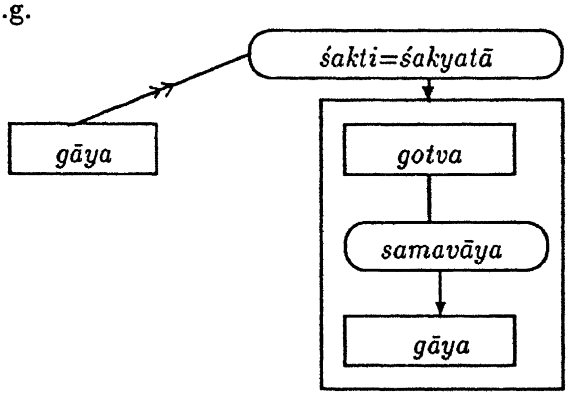


Figure 22

It is the *śakyatā avacchedaka* which is said to determine the meaning or referent of the *pada*.[Shaw,1985] *śakyatā avacchedaka* is defined as

vācyatve sati
vācyavṛttitve sati
vācya upasthiti prakāratvam[Jhalakikara,1928;p580]

i.e, *śakyatā avacchedaka* is one
which itself is the meaning of the referent,
which exists in the referent,
and also appears as a qualifier in the recollection of the referent of the *pada*.[Guha,1979;p18]
Thus, e.g. in the above example, *gotva* is the *śakyatā avacchedaka* of the referent of the term *'gāya'*. Hence the referent of the term *'gāya'* is any

arbitrary *gāya* (*sāmānya gāya*).

When one wants to refer to a particular cow, one uses either her name or a pronoun. In that case the *śakyatā avacchedaka* will not be just *gotva*. For example, if the name of the cow is *Kapilā*, then the *śakyatā avacchedaka* will be both *Kapilātva* and *gotva*.

3.3.4 summary

Thus one can see that, though *avacchedaka* is used in different senses, basically it is used to determine the range of the locus of the abstract property. For example, in case of *avacchedaka* of *buddhimattā* it fixes the locus of buddhimattā to somebody or anybody with *manuṣyatva* property. In case of *vyāpti*, whether it is some locus or any locus, in case of referent, whether it is a particular cow or any cow. And this is what mode of cognition is for. In the case of mode of cognition, it is the perceiver who has *avacchedakas* involved in his cognition. On the other hand when a speaker uses *avacchedakas*, then the sole purpose of the introduction of these *avacchedakas* is to precisely tell what he means, by specifying the ranges of the loci of abstract properties.

The *avacchedakas*, thus have two aspects - first one is to specify the range of locus of abstract property which is getting *avacchinna* (limited) by this *avacchedaka*, and second one is to denote a *sāmānya* object. The restricted variabls can capture only first of these two aspects. *avacchedaka* themselves serve as a quantifier since one which gets *avacchinna* denotes a *sāmānya* objec. However in case of restricted variables, one has to make use of quantifiers explicitly for quantification purpose.

Chapter 4

Techniques in Navya Nyāya

In this capter we discuss very widely used technique in NN viz. *anugama*. *anugama* is a technique of generalisation. It is widely used in definitions. Generalisations is effected either by using relations or by using properties. These two methods of *anugama* are known as *samsarga vidhayā anugama* and *prakāra vidhayā anugama* respectively. In the case of *samsarga vidhayā anugama*, the abstraction is done by mentioning the relation between two objects while in the case of *prakāra vidhayā anugama*, the qualifiers of all the objects in the particular cognition are mentioned, thereby eliminating the undesired readings. There is a striking similarity between the *samsarga vidhayā anugama* and the relation contraction in conceptual graphs. For a more complex example of *samsarga vidhayā anugama* see Appendix D. An example of *prakāra vidhayā anugama* – abstraction through the properties is given in Appendix C.

4.1 *anugama*

In western logic variables are used for stating universal laws. Old *nyāya* was using a pair of relative pronouns that-which (*yat* - *tat*) in the definitions. But according to NN school, these relative pronouns stand for free variables.

"Such a sentence may serve the purpose of universal sentence only by substituting names for the free variables in succession. Still such a substitution yields a singular sentence. Hence these philosophers use the technique of *anugama* to avoid using relative pronouns altogether."[Bhattacharya,1990b;pp 108-109]

4.1.1 *samsarga vidhayā anugama*

Here we start with the definition of *bhrama* (false cognition) and show how we arrive at the *samsargavidhayā anugama* by generalising the definition with the help of relations.

Bhrama is defined as
bhramah = yatra yat nāsti tatra tasya jñānam
i.e.,
bhrama = vastu mem kisī aise dharma kā jñāna honā —(a)
jo usa vastu me nahmi rahatā —(b)
udā: rajju ko dekhakara sarpa kā jñāna honā yaha bhrama hai.
Thus there are two conditions for a cognition to be false.

1. According to the first condition *rajjvao sarpatvasya jñānam.*
   i.e., *rajju mem sarpatva kā jñāna honā*
   bhrama is a *jñāna*. Every *jñāna* has a *viṣaya*. rajju is the *viṣaya* of the given *jñāna*. Hence, *rajju* has *viṣayatā* in it. The mode of cognition of *rajju* is *sarpatva*. Therefore *sarpatva* is the *avaccedaka* of the *viṣayatā* in *rajju*. (*avacchedaka* as a mode of cognition is discussed in previous chapter).

This is represented as

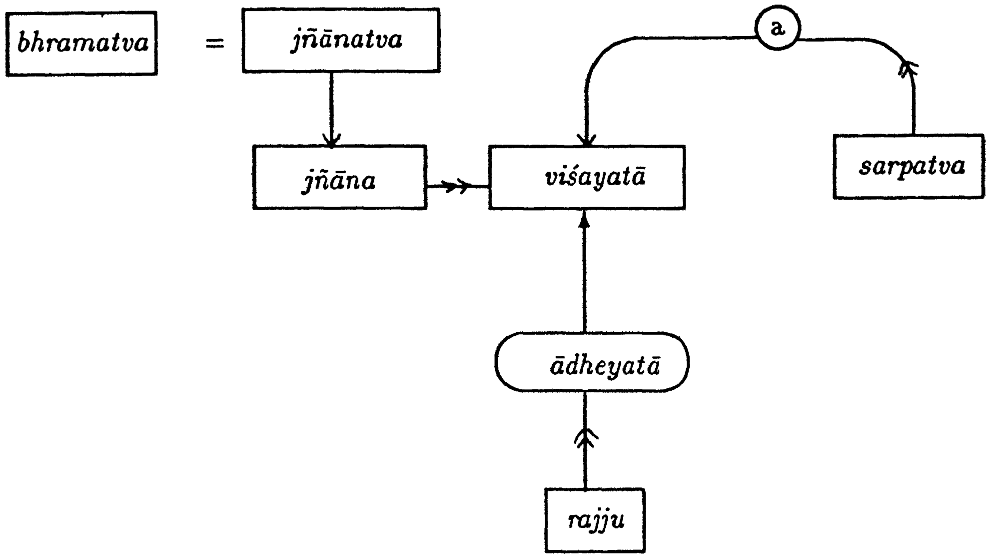


Figure 1

2. The second condition denies the presence of *sarpatvam* in *rajju*.

   sarpatvam rajjao nāsti.

   sarpatva rajju mem nahim hai.

   sarpatva mem rajju kī ādheyatā kā abhāva hai.

   srapatva mem rajju nirūpita ādheyatā kā abhāva hai.

   This is represented as

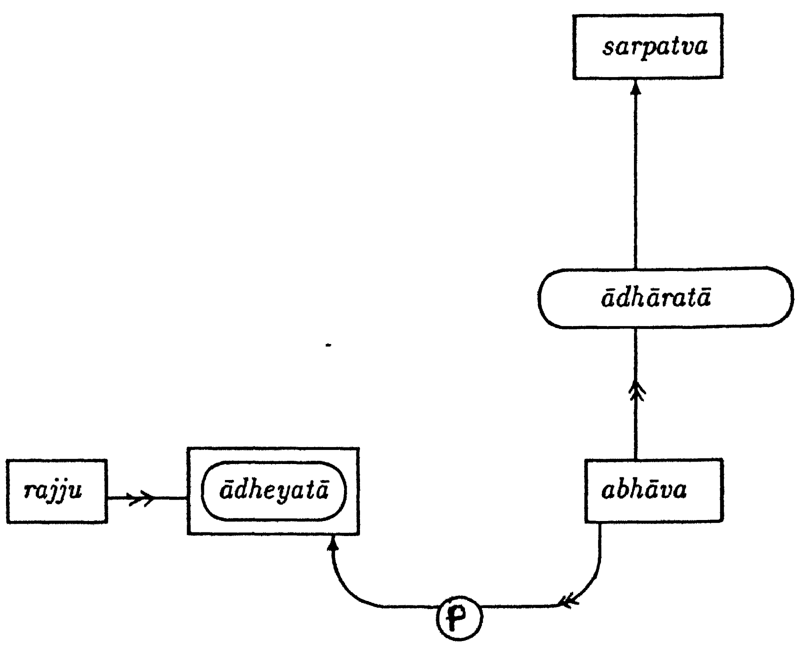


Figure 2

combining Figures Figure 1 and Figure 2, we get

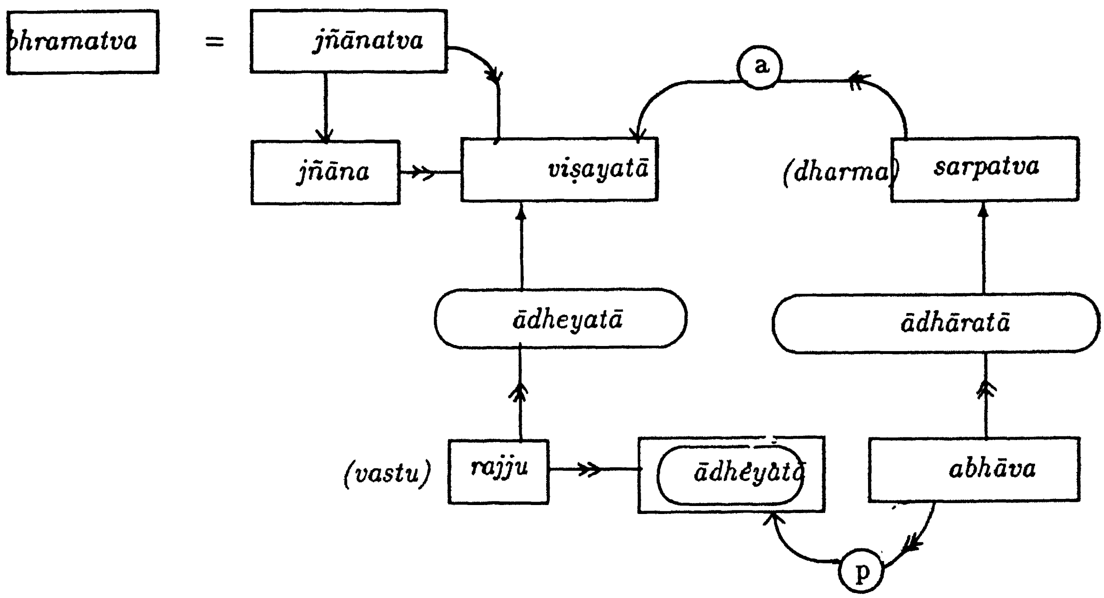
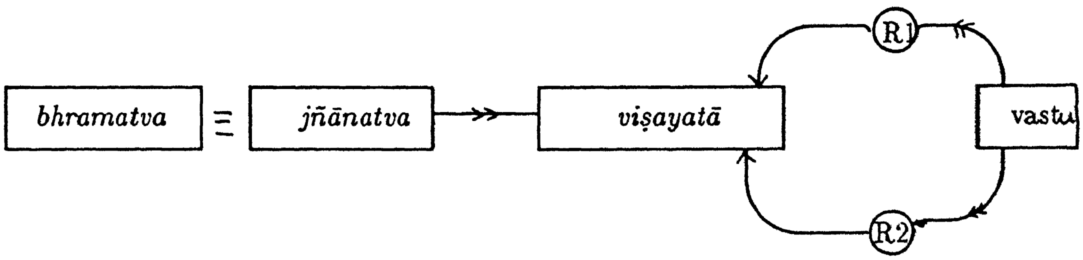


Figure 3

This can be drawn in compact form as



where

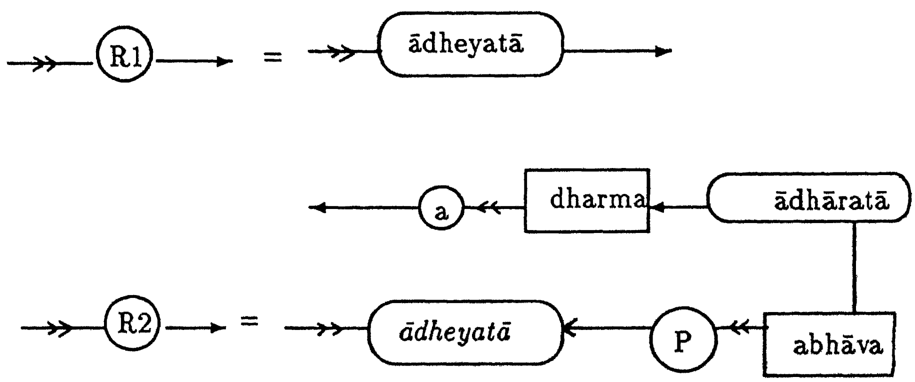


Figure 4

Thus

bhramatva = *vastu viśiṣta viṣayatā nirūpaka jñānatva*
vaiśiṣtya
sva ādheyatā (R1) evam *sva ādheyatā abhāvavat dharma avacchinnatva* (R2) *ina ubhaya sambandhom se*, where *sva* refers to *vastu*.

This technique of *samsargavidhayā anugama* is very similar to the concept of relation contraction in Conceptual Graphs.

4.1.2 Relation Contraction

The sentence
'The total number of floppies in the stock room is 15' [Sowa,1985;p114]
can be represented as

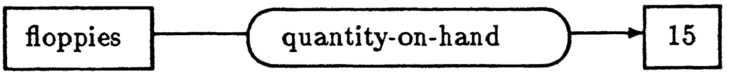


Figure 5

where quantity-on-hand stands for
relation quantity-on-hand(x,y) is

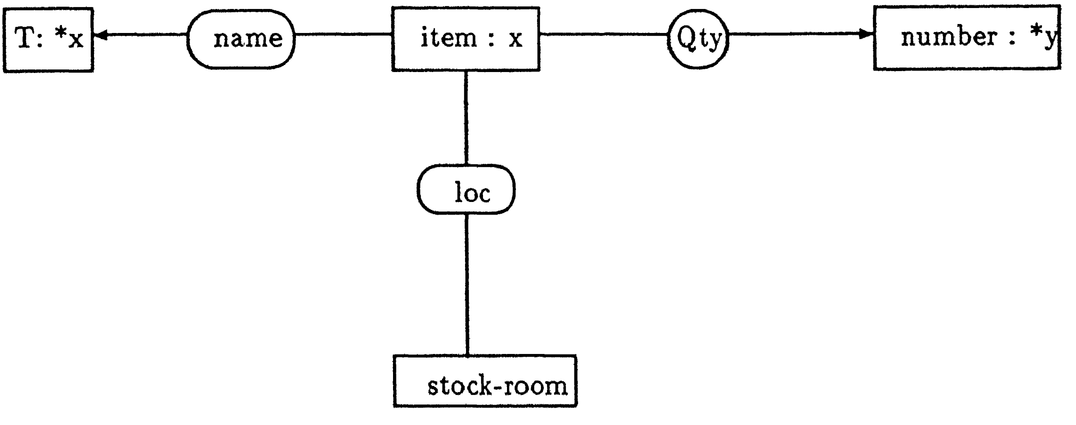


Figure 6

Chapter 5

Quantifiers in Navya Nyāya

5.1 Introduction

In ordinary language, we use the notion of '*sāmānya*', quite naturally and frequently. For example, when one says,

'*koī ladakā āyā hāī*',

though he was a definite boy, yet his identity being not revealed (with the assumption that it is immaterial in the given context), he is a '*sāmānya*' boy.

Similarly if somebody says,

'*koī bhī pen le āo*',

one is going to bring some pen. The pen that will be brought will be a definite one. But still it is an arbitrary pen, i.e., properties in this pen, other than pen-ness are unimportant. In other words, though this is a particular (*viśeṣa*), still it is arbitrary (*sāmānya*).

In natural deduction also we make use of the concept - '*sāmānya*'. Having shown that the sum of interior angles of an arbitrary (*sāmānya*)

triangle is 180^0, we generalise it to 'all triangles have the property that sum of their interior angles is 180^0'. Also after establishing that bisector of an angle exists, we give it a name and call it the bisector of the given angle.

In the first example, the triangle chosen, though is particular, none of the special properties of it are considered, except that it is a triangle. Thus it is viewed as '*sāmānya*', though it is '*viśeṣa*'. In other words, it is '*viśeṣa, avacchinna by sāmānya rūpa*'. In the second case, the bisector is an arbitrary bisector (*sāmānya*), but once a name is given to it, it becomes *viśeṣa.* Thus the bisector can be described as *viśeśa rūpa se avacchinna sāmānya* object.

This concept of *sāmānya* is very close to the concept of Kit Fine's 'arbitrary objects'in Fine(1985b)

According to Kit Fine,(Fine,1985b;p viii)

> *"the true potential of the generic approach is only fully realised when the quantifiers, as standardly conceived, are dropped altogether and the arbitrary objects themselves are made the sole vehicle of the generality."*

NN does not make use of quantifiers and variables. On the other hand it uses abstract properties, *avacchedakas* and the concept of *nirūpya-nirūpaka bhāva*, as we have seen in the previous chapter.

In what follows we show how the NN theory is close to the theory of arbitrary objects, give the semantics of Copi's system, in brief, in the light of arbitrary objects, and finally show how this semantics is captured by the NN diagrams.

5.2 Arbitrary Objects

The theory of arbitrary objects has three notions.

(a) There are arbitrary objects.

nyāya accepts the existence of arbitrary (*sāmānya*) objects. E.g. it allows the expressions such as *ghatatvavat* to mean '*sāmānya ghata*'.[Jha,1965;pp 270-312]

(b) The arbitrary objects are related with other arbitrary objects by dependency relation. According to *naiyāyikas*, it is the abstract property that depends on the other abstract property(ies). Abstract properties have *nirupya nirūpaka bhāva* between them. [Ingalls,1951;p47]

(c) The third notion is that of value assignment to the arbitrary objects. In NN it is the *avacchedaka* which governs the values that an arbitrary object can receive simultaneously. E.g. *bālakatva se avacchinna vyaktitva* will restict the values *vyaktitva* can assume, to all *bālaka*.

At the same time the dependency relation also constrains the values a dependant object can receive. E.g. *āyodhyā-nagarī se nirūpita nāgarikatva evam bālakatva se avacchinna nāgariktva* can have only *bālaka* resident in *āyodhyā nagarī* as its value.

5.3 Copi's system

The description of Copi's system in the light of arbitrary objects as adapted from Kit Fine's 'Reasoning with arbitrary objects' is presented below. [1985b]

The quantification rules for Copi's system are

UI: $\forall x\ \Phi(x)\ /\Phi(t)$ UG: $\Phi(a)\ /\forall x \Phi(x)$

EI: $\exists\ x\ \Phi(x)/\Phi(a)$ EG: $\Phi(t)/\exists\ x\ \Phi(x)$

The restriction for applying the rules EI and UG are as given below.

(a) Local restriction: The letter 'a' should not occur in Φ in any application of UG and EI.

(b) Novelty: In any application of EI, the letter 'a' should not have been occured in the derivation.

(c) Weak Flagging: If the letter 'a' in has been used in an appliation of EI, one can't apply UG to this formula.

(d) Independence: In any application of UG, no letter occuring either in the conclusion or suppositions to the inference can be identical to or depend on the letter 'a'.

5.3.1 Dependency Diagrams

The dependency diagrams are helpful to keep a running check on the correctness of derivations. These diagrams are drawn making use of typographic distinction between the 'a' terms of UG and EI.

> "The dependency diagrams, especially employed in connection with a typographic distinction between UG and EI-terms, provide a highly effective way of checking the correctness of derivations within C"[Fine,1985a;p95].

The rules for drawing dependency diagrams are given below.

The letter 'a' occuring in UG and EI is called an *instantial term.* We call following Kit Fine, instantial terms corresponding to the applications of EI and UG rules as $\exists$-*instantial term* and $\forall$-*instantial term* respectively. In any application of $\exists x\ \Phi(x,b,c)/\Phi(a,b,c)$ of EI or $\Phi(a,b,c)/\forall x\ \Phi(x,b,c)$ of UG the letters b and c are called *given terms.*

(a) Rule for EI: Introduce a '•' corresponding to the $\exists$-instantial term and label it. The label should not be present earlier in the diagram. If a label already exists, then derivation can't be continued. [This takes care of novelty.]
Introduce '$\star$'s corresponding to the *given terms* that are not already present. Join all the nodes corresponding to given terms to the node corresponding to $\exists$-instantial term by arrows($\rightarrow$).

(b) Rule for UG: If ∀-instantial term is not already present in the diagram, introduce an '⋆' corresponding to it. Corresponding to each given term that is not present in the diagram, introduce an '⋆'.

If ∀-instantial term is already present in the diagram, two situations are possible.

- It is connected to other nodes. In this case, if the other nodes to which it is connected do not appear as given terms, only then UG can be applied, otherwise the derivation fails. [This takes care of Independence].
- It is not connected to other nodes. In this case UG can be applied.

Two different symbols for ∃-instantial terms and ∀-instantial terms assure the satisfiability of Weak Flagging.

We now give here two examples of derivations and the corresponding dependency diagrams.

Example 1. Derive ∀x∃yFxy from ∃y∀xFxy.
At each stage of derivation we write down the rule used and show the status of dependency diagram.

			Dependency diagram
1.	∃y ∀xFxy		
2.	∀xFxb	EI	• b
3.	Fab	UI	• b
4.	∃yFay	EI	• b
5.	∀x ∃yFxy	UG	a ⋆ • b

Example 2. Here we show how the dependency diagram stops us from using ∃y ∀xFxy from ∀x ∃yFxy.

			Dependency diagram
1.	∀x ∃yFxy		
2.	∃yFay	UI	
3.	Fab	EG	a ⋆→• b
4.	∀xFxb	UG	

Fourth step is not possible as it violates the rule for UG, viz., F contains 'b' - a given term which depends on 'a'. Hence UG can't be applied for 'a' unless 'b' is eliminated from the expression.

The semantics of the ∀-instantial terms and ∃-instantial terms in terms of arbitrary objects is

> "the ∀-instantial terms shall denote unrestricted A-objects; the ∃-instantial terms from inferences $\exists x\Phi(x)/\Phi(a)$ shall denote putative Φ-ers, dependent upon the objects denoted by the given terms to the inference"[Fine,1985; p95].

5.4 *nyāya*

The interpretations of ∃-instantial terms and ∀-instantial terms in *nyāya* are '*viśeṣa rūpa se sāmānya*' and '*sāmānya rūpa se viśeṣa*' respectively. First we explain the phrases '*viśeṣa rūpa se sāmānya*' and '*sāmānya rūpa se viśeṣa*' and then show how these are equivalent to the semantics of instantial terms in terms of arbitrary objects.

Let us reconsider the examples discussed in the introduction of this chapter. The sentence

kala koī ladakā āyā thā,

though is for a particular boy, who had come yesterday, he is a definite boy. But the pecularity being not specified, other than that he had come yesterday, he is a '*sāmānya*' boy, having unspecified *vaiśiṣtya*. Or in other words, he is '*viśeṣa rūpa se avacchinna sāmānya ladakā*'. In terms of arbitrary objects, this is an arbitrary 'a' that Φ's - a putative Φ-er.

The sentence

koī bhī ladakā padha sakatā hai,

says every boy has an ability to read. Now when we make use of this sentence in the derivation, we instantiate the boy with a particular boy. But in derivation we don't make use of any other property in the boy, other than that he is a boy. Though a boy is particular i.e.

viśeṣa, he is still cognised as a '*sāmānya*'. Hence he is '*sāmānya rūpa se viśeṣa*'.

In terms of dependency diagrams, a '•' corresponds to an object that is '*viśeṣa rūpa se sāmānya*' and a '⋆' corresponds to an object that is '*sāmānya rūpa se viśeṣa*.

Now let us see how NN represents sentences whose First Order Predicate Calculus (FOPC) representation involves quantifiers and variables.

The sentence 'Mohan loves Kapila' in FOPC is represented as

loves(Mohan,Kapila)

where Mohan and Kapila are individuals.
Here loves is a predicate. But NN expression involve only terms and their properties. So it is necessary to use the semantics of the argument positions in the predicate. This can be represented, therefore, as

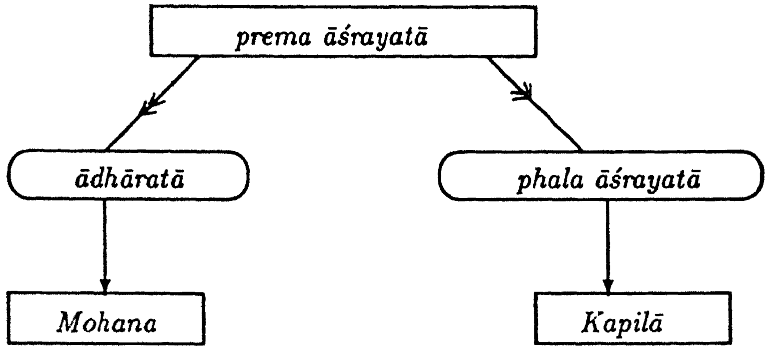


Figure 1

Since *ādhāratā* can be represented simply by → arrow,

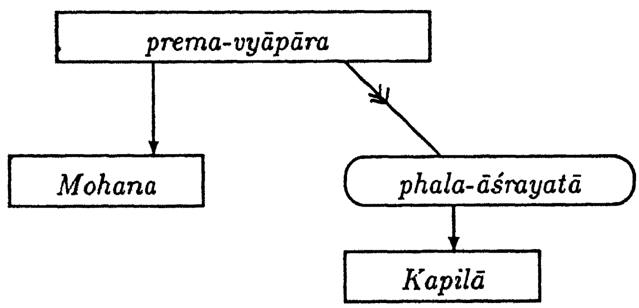


Figure 2

prema vyāpāra is *prema* and *phala āṣrayatā* of *prema vyāpāra* is *priyatva.*

One can therefore redraw the above figure as

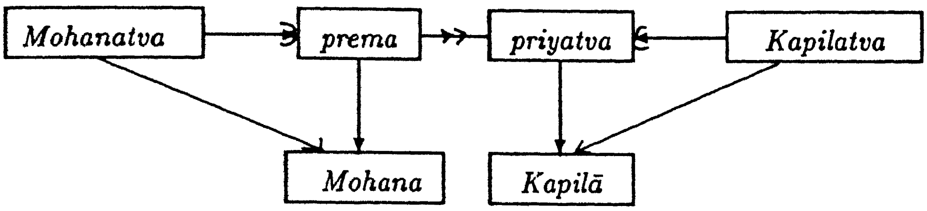


Figure 3

Now the representation for

koī manuṣya kisī gāya se prema karatā hai

in FOPC is (assuming that variables are sorted)

$\exists x \exists y loves(x,y)$

and the NN representation is

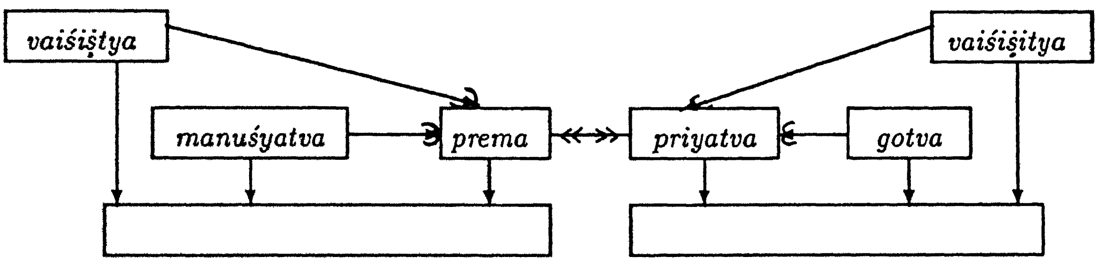


Figure 4

The *vaiśiṣṭya* in *gāya* being '*viśiṣṭa manuṣya niṣṭha prema nirūpita priyatva*'
and the *vaiṣiśtya* in *manuṣya* being '*viśiṣṭa gāya niṣṭha priyatva nirūpita prema*'

The dependency diagram can then be drawn as

a • ▸ b

where the node 'a' corresponds to *manuṣyatva evam vaiṣiśtya se avacchinna premavat* and 'b' corresponds to *gotva evam vaiṣiśtya se avacchinna priytvavat.* Since *prema* and *priyatva* have *nirūpya nirūpaka bhāva*, 'a' and 'b' depend on each other.

Semantically it means, the two formulae $\exists x \exists y loves(x,y)$ and $\exists y \exists x loves(x,y)$ are equivalent.

Shown below is the equivalence of these formulae, using Copi's system and the corresponding dependency diagrams.

$\exists x \exists y loves(x,y)$			—	$\exists y \exists x loves(x,y)$		
$\exists y loves(a,y)$	EI	a •	—	$\exists x loves(x,b)$	EI	• b
loves(a,b)	EI	a •→• b	—	loves(a,b)	EI	a •←• b
$\exists x loves(x,b)$	EG		—	$\exists y loves(a,y)$	EG	
$\exists y \exists x loves(x,y)$	EG		—	$\exists x \exists y loves(x,y)$	EG	

The formula

$$\exists y \forall x loves(x,y) \wedge (y=Kapila) \qquad (1w)$$

in FOPC (where Kapila is assumed to be name of a cow), stands for

hara bālaka Kapilā nāmaka gāya se prema karatā hai (1)

Since in NN the canonical form is 'a has b',
we paraphrase (1) as

hara bālaka mem Kapilā nāmaka gāya ke prati prema hai,

or as

jahām jahām bālakatva hai vahām vahām Kapilā ke prati prema hai,

or as

bālaktva Kapilā se nirūpita prema se vyāpya hai.



Figure 5

This can further be expanded as

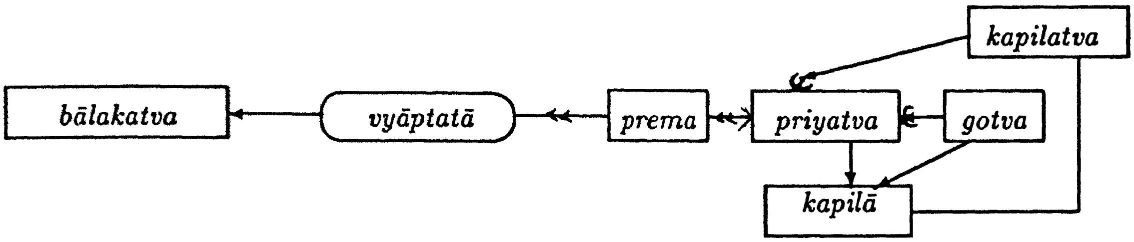


Figure 6

Before presenting the dependency diagram, we first give the meaning of *vyāpyatā*. *vyāpyatā* is the relation of pervasion.

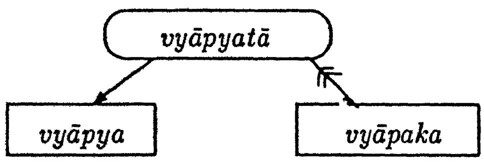


Figure 7

Hence given a *vyāpya* (the one which is pervaded by), there always exists a *vyāpaka* (the one which pervades), but not the other way. E.g. smoke is pervaded by fire. Hence given an instance of smoke (which is *sāmānya rūpa se avacchinna viśiṣta* smoke), there exists a particular instance of fire. Now the fire though is an arbitrary fire has a property that it pervades the given instance of smoke. Hence it is *viśeṣa rūpa se avacchinna sāmānya* fire. Thus, there will always be a '⋆' corresponding to a *vyāpya* and a '•' corresponding to a *vyāpaka*.

Therefore the dependency diagram for Figure 6 will be

a ⋆ • b

where 'a' corresponds to *bālaktva* and 'b' to *Kapilā*.

Below we give few sentences in natural language and their representations in FOPC and NN, along with the dependency diagrams.

- Sentence : *hara bālaka kisī na kisī gāya se prema karatā hai.*

- FOPC : ∀x∃yloves(x,y) (2w)
- NN :

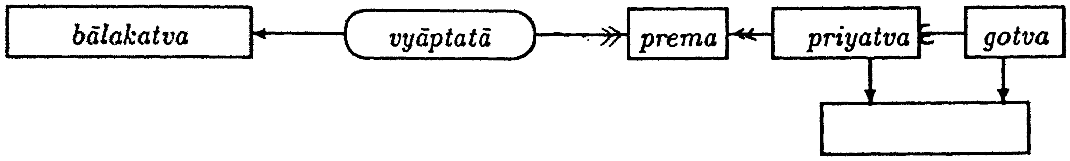


Figure 8

- Dependency Diagram: a ⋆⟶• b

Note that the fact that Expression (2w) can be derived from the Expression (1w) but not vice versa, is very naturally reflected in the corresponding NN diagrams, viz. Figure 6 and Figure 8. Figure 8 is a natural genrealisation of Figure 6 while Figure 6 is a special case of Figure 8.

- Sentence : *hara gāya se koī na koī bālaka prema karatā hai.*
- FOPC : ∀y∃xloves(x,y)
- NN :

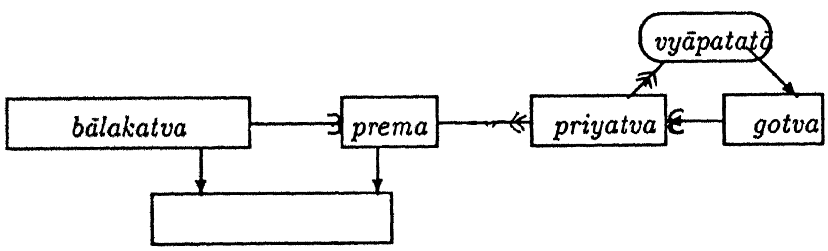


Figure 9

- Dependency Diagram: a •⟵⋆ b

- Sentence : *hara bālaka hara gāya se prema karatā hai.*
- FOPC : ∀x∀yloves(x,y)
- NN :

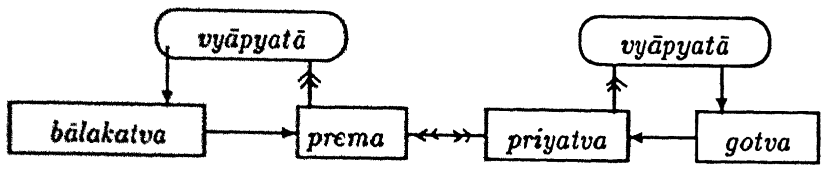


Figure 10

- Dependency Diagram: a ⋆ ⋆ b

- Sentence : *eka bālaka eka gāya se hara ghara mem hara dina prema karatā hai.*
- FOPC :∃s∃y∀u∀v F(s,y,u,v)[s: *bālaka*, y: *gāya*, u: *ghara*, v: *dina*]
- NN:

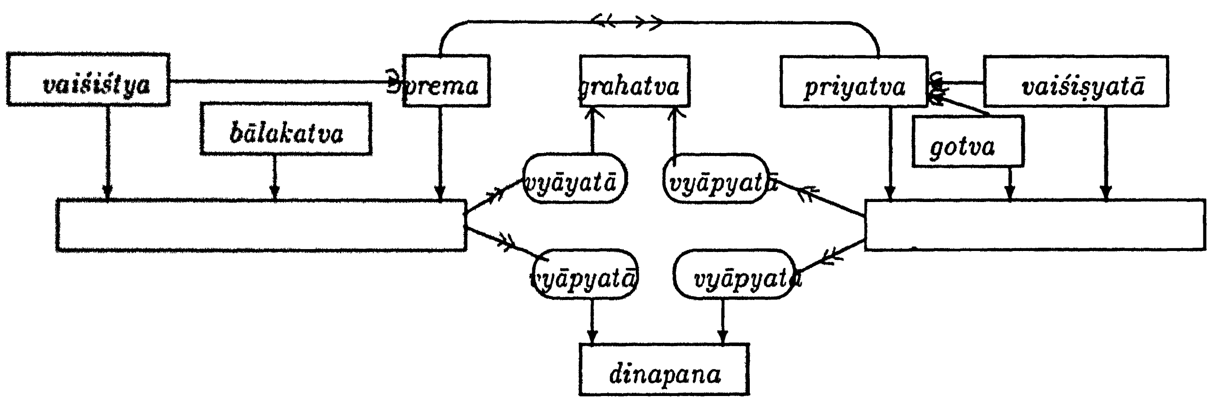


Figure 11

- Dependency Diagram: u ⋆ ⋆ v • s • y

Since extra lines between •s and ⋆s can always be introduced in the dependency diagrams and the order of independent nodes being immaterial, some of the formulae that can be derived are given below.

	Formulae	Dependency Diagram
1.	∃y∃s∀u∀vFsyuv	⋆ u ⋆ v • s • y
2.	∃y∃s∀v∀uFsyuv	⋆ u ⋆ v • s • y
3.	∃s∃y∀v∀uFsyuv	⋆ u ⋆ v • s • y
4.	∃s∀u∃y∀vFsyuv	u ⋆→•y ⋆ v • s
5.	∃s∀u∀v∃yFsyuv	u ⋆→•y • s v ⋆↗
6.	∃y∀u∀v∃sFsyuv	u ⋆→•s • y v ⋆↗
7.	∃y∀u∃s∀vFsyuv	u ⋆→• s ⋆ v • y
8.	∀u∃s∀v∃yFsyuv	u ⋆→• s v ⋆→• y
9.	∀u∀v∃s∃yFsyuv	u ⋆ ⋆ v x y

Note that one of the possible dependency diagrams is u⋆→•s v⋆→•y which corresponds to branching quantifiers, for which there is no equivalent FOPC formula.

Chapter 6

Conclusion

6.1 What has been achieved

- The diagrams drawn using Conceptual graphs like notation for representing the NN expressions, help a modern student to have a physical view of the NNEs. Since this notation maintains a one-to-one correspondence between the diagram and the given NNE, it produces a faithful image of the gven NNE. This facilitates a modern student in viewing and listening to a text on NN.

- It is necessary to note a difference in the concept of relation in NN and western logic. In western logic a term and a relation have totally different status. In NN, however, any relation is a property residing in its *anuyogi*. This property is a special one, as it has an expectancy for the other term, viz. *pratiyogi* with which it is related. As such this property is always determined by its *pratiyogi*. Also there is an altogether different treatment of *abhāva* in NN. Hence the notation thus evolved, though have a origin in conceptual graphs, is a totally different version of it.

- On the one hand, this thesis has established a bridge between NN and the conceptual graphs by providing a notation for representation. On the other hand, it has also filled a gap at the conceptual level, by providing an interpretation of *avaccedakas* in terms of arbitrary objects. It is known since Ingalls that NN does not use quantifiers but make use of combination of abstract properties and *avacchedakas*. Stalls used the notion of restricted variables. But still could not capture the concept, since the restricted variables just capture one of the aspects of *avaccedakas* - viz. assigning values to a variable. But the other aspect of it, viz. quantification is not captured, as in case of restricted variables also one has to explicitly use the quantifiers. The concept of arbitrary objects, however, captures the concept of *avaccedaka* in its true spirit.

6.2 Future Work

- Only those aspects in NN that have a counterpart in FOPC are dealt with. Comarative study of *abhāva* and the negation may give a new insight.
- The comaprative study of concept of *pratibandhaka* with its counterpart in western logic - default reasoning is another potential area.
- We have studied only one kind of *avacchedaka* viz. *dharma avacchedaka*. There are many different types of *avacchedakas* - *deśa, kāla, sambandha*. These can also be studied.
- The interpretaion of *avacchedakas* in terms of arbitrary objects is yet to be discussed with *naiyāyiks*.

Finally, as stated in the introduction, our interest is not in the philosophical or historical aspects of the NN school. Can the concepts used therein be put to actual use? - This is the question, answer to which we are looking for. Establishment of a bridge is an important milestone in this regard.

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Appendix A

Correction in Ingalls derivation

Ingalls treats the two *pratiyogitās* viz. that of *bheda* and the *atyanta abhāva* to be same, and hence arrives at a wrong conclusion that $- \dot{-}x \doteq x_1$ cannot be derived. (Ingalls,1951;p71)
To understand the point clearly, and to point out the fallacy in his argument, complete proof is produced below.

About Ingalls Notation:
-x stands for x - *abhāva*
$\dot{-}x$ stands for (difference of x) x-*bheda*
c stands for the *pratiyogi*
x_1 stands for x-ness.
(a) $- - x \doteq x$;
(b) Therefore $- - \dot{-}x \doteq \dot{-}x$;
(c) c of $- - \dot{-}x \doteq$ c of $\dot{-}x$;
(d) $- \dot{-}x \doteq x$

Let us represent these in terms of diagrams and see, the fault in the argument.
(a) is represented as

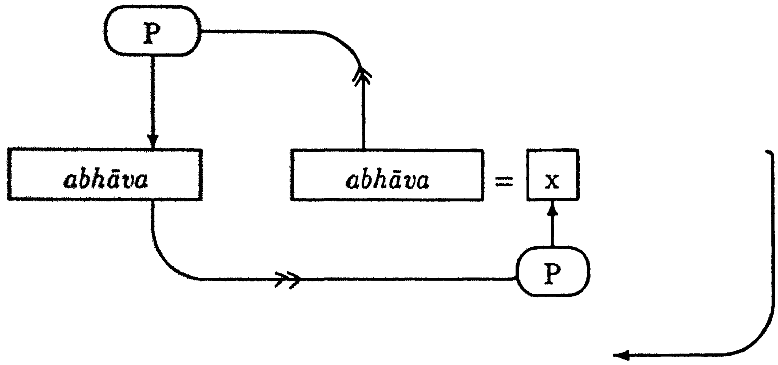


Figure 1

Read this in the direction of the → viz, x *ke abhāva kā abhāva* = x.
Replacing x by ¬x, in (a)
i.e,

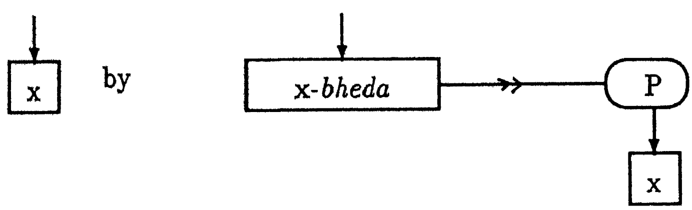


Figure 2

we get,

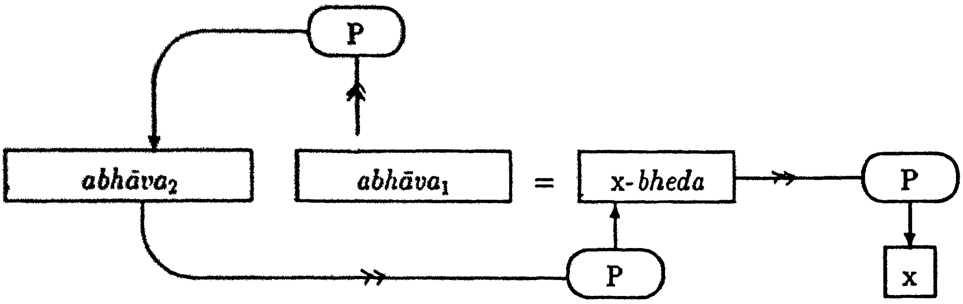


Figure 3

which is the representation for (b).

From the Figure we see that there two *pratiyogis* of x-*bheda* one corresponding to x-*bheda* viewed as a *bheda* and the other x-*bheda* viewed as an *atyanta abhāva*. First one is *pratiyogi* of the x-bheda viz. x, and the second is *pratiyogi* of *abhāva*$_1$, viz, x-*bheda kā abhāva*$_2$.

These two *pratiyogitās* are not comparable, as one is the *pratiyogi* of *anyonya abhāva* (or *bheda*) and the other one is that of the *atyanta abhāva*. In other words their *avacchedakas* are different – in the case of *bheda* it the *tādātmya sambandha* (identity relation) and in the case of *atyanta abhāva* it is the *samavāya sambandha* (inherence relation). Hence (d) can't be derived from (c), as has been done by Ingalls.
If at all the two *pratiyogitās* are to be compared, they should be of similar kind.

Thus, if in the above Figure, *pratiyogitā* in x-*bheda* is replaced by that of the *atyanta abhāva*, we get

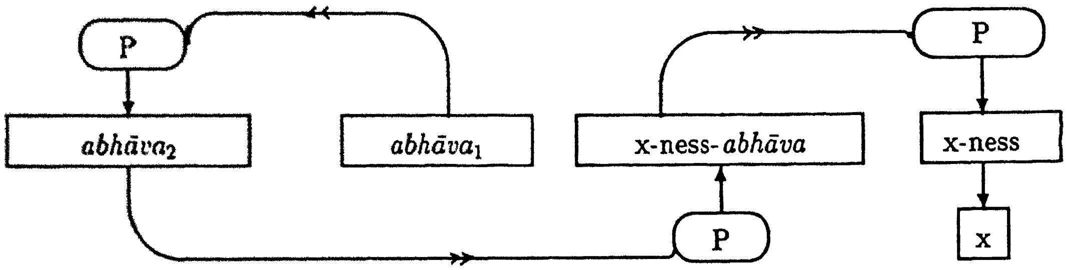


Figure 4

Now, from the above Figure, we can get
pratiyogi of *abhāva*$_1$ = abhāva$_2$ *of* x-bheda ($= - \dot{-}x$)
and pratiyogi *of* x-bheda = x-*ness* = (x_1)
Therefore $- \dot{-}x = x_1$, *using Ingalls notation.*

Appendix B

pratiyogitā

B.1 Technological Clashes

The term pratiyogitā *in NN is overloaded. This term is used in two different contexts -*

- *in the context of relations, and*
- *in the context of* abhāva.

The first one is known as sāmsargika pratiyogitā, *and the second one as* abhāviya pratiyogitā.

B.1.1 *abhāviya pratiyogitā*

pratiyoga *means to oppose .* *Hence* pratiyogitā *is opposition. In the context of* abhāva, *the object which opposes (or removes) the* abhāva *is called the* pratiyogi *of the* abhāva. *For example, in the case of book-*abhāva, *the presence of book on the table will remove its absence from*

the table. Hence book is the pratiyogi *of book* abhāva.

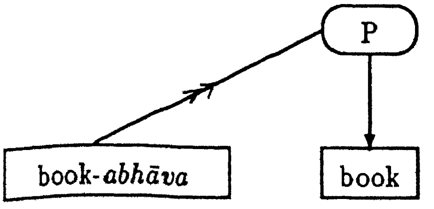


Figure 1

B.1.2 *sāmsargika pratiyogitā*

A relation in NN is a relation of something 'a' in something 'b'.

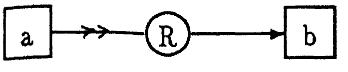


Figure 2

The terms 'b' and 'a' are called anuyogi *and the* pratiyogi *of the relations R, respectively.*

For example, Rāma *has son-ness determined by* Daśaratha, *is represented as*

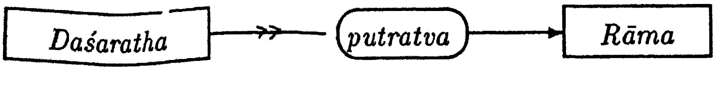


Figure 3

Daśaratha *being the* pratiyogi, Daśaratha *has* pratiyogitā *of* putratva *relation* .

B.2 Consistency in terminology

At the outset these two usages seem to be totally unrelated. But if we relate these to their natural language counterparts, we will see the striking similarity between the two.

Consider the sentence-
Daśaratha ke putra Rāma
This can be represented as

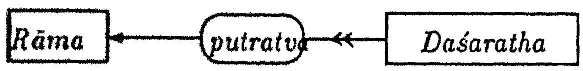


Figure 4

Here the pratiyogi *of the relation* putratva *is* Daśaratha.

This can be further elaborated as

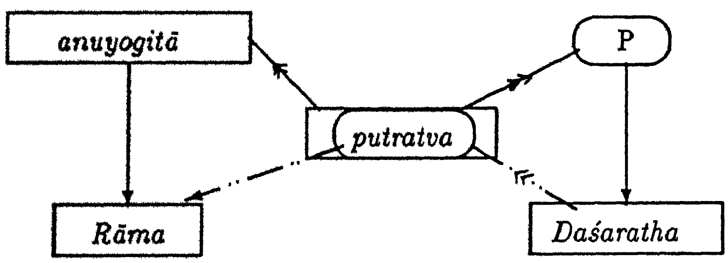
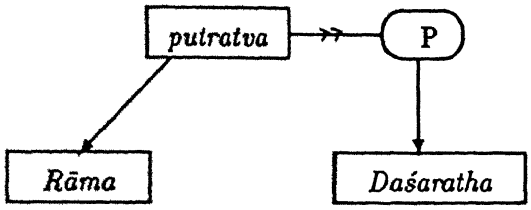


Figure 5

Thus we have

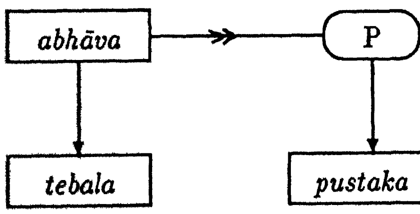


— (I)

Figure 6

This says,
Rāma *has* putratva, *whose* pratiyoigtā *is in* Daśaratha.
i.e,
Rāma mem Daśaratha nirūpita (kā) putratva hai—*-(1a)*

Now consider the sentence
tebala para pustaka kā abhāva hai.——*(2a)*
This will be represented diagramatically as



— (II)

Figure 7

Note the similarity between (I) and (II) which correspond to the natural language sentences (1a) and (2a) respectively.

Appendix C

prakāra vidhayā anugama

The final definition of vyāpti *by* raghunātha śiromaṇi *(*siddhānta lakṣaṇa*) is*
hetu ke *(*kisī bhī*)* adhikaraṇa mem vṛtti *(*kisī bhī*)* abhāva ke apratiyogi kā hetu ke sātha sāmānādhikaraṇya hī vyāptī hai. —*(1)*

Let 'l' be any locus of hetu *'h',*
let 'a' be any absence in the locus 'l',
and let 's' be an instance of sādhya *in locus 'l',*
then 's' should not be the pratiyogi *of the absence 'a' in 'l'.*
Then Sentence (1) is expressed in FOPC as

$\forall h\ \forall l\ \forall a\ \exists a$ [hetu(h) $\wedge$ sādhya(s) $\wedge$ abhāva(a) $\wedge$ $has(l,h)$ $\wedge$ $has(l,s)$ $\rightarrow$ $\neg$ $has(s,$pratiyogitā$(a))]$ -(2)

The prakāra vidhayā anugama *of (1) is [Shukla, 1984;p187]*
vastu samānādhikaraṇa vastuniṣṭha abhāva nirūpita
pratiyogitāniṣṭha pratiyogitā nirūpita
abhāva niṣṭha avacchedakatā nirūpita
vṛttitva niṣṭha avacchedakatā nirūpita
adhikaraṇa niṣṭha avacchedakatā nirūpita

avacchedakatā vyāpti hai.

Thus vyāpti *is defined as*
The avacchedakatā *in hetu,*
where this avacchedakatā *is determined by the* avacchedakatā *in* vṛttitā,
which in turn is determined by the avacchedakatā *in the* abhāva, *occuring in the locus of* hetu.
The avacchedakatā *in above mentioned* abhāva *is determined by the* pratiyogitā *of the* abhāva *in the* sādhya *that is occuring in the same locus as that of* hetu.

Following is the diagramatic representation of this definition.

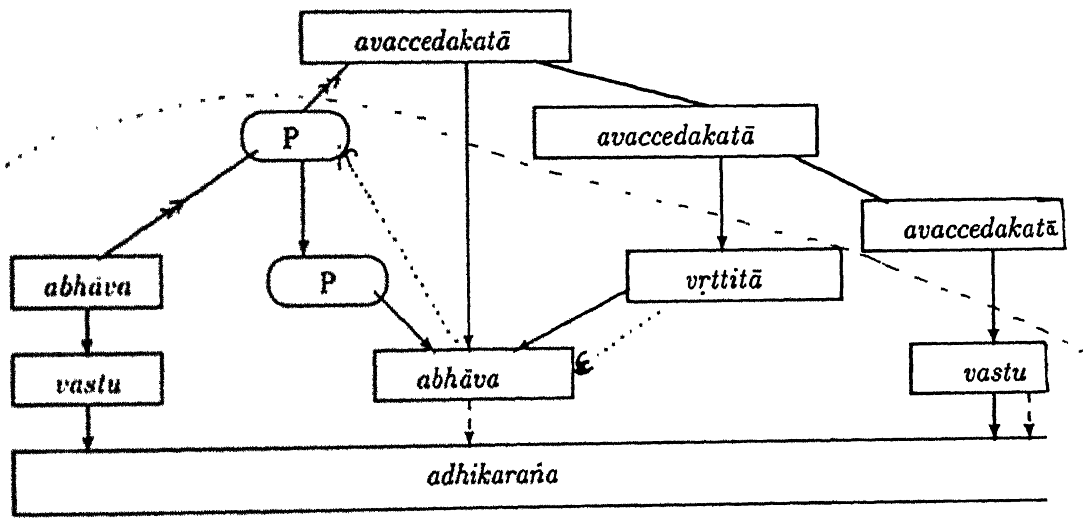


Figure 1

Here we note that the avacchedakatās *correspond to the universal quantifiers in (2).*

Thus the avacchedakatā *in* hetu *says, it is not any particular locus (*adhikaraṇa*) of* hetu *but any locus of the* hetu. *Similarly the* avacchedakatā *in the* vṛttitā *says, it is not particular* abhāva *but any* abhāva *in the locus, and finally,* pratiyogi *of this* abhāva *should not be* sādhya. *Now*

a pratiyogi *of* abhāva *of X can be any object belonging to the class X. e.g.* pratiyogi *of* abhāva *of a book can be a blue book, red book, thick book, etc. So the* sādhya *should have absence of* pratiyogitās *existing in each of these. Since these* pratiyogitās *are qualified by the* abhāva, abhāva *has* avacchedakatā.

Appendix D

Use of anugama to specify the relations

Here we give an example of samsarga vidhayā anugama *in the definition of* tat-nirūpita-svatva *(owned-by-x-ness).[Shukla,1984;p147]*

If a person purchases a thing, then that thing is owned by him. The object will have a property (owned-by-x)-ness as long as the following conditions are satisfied.

(a) x has purchased the thing.

(b) the time under consideration is greater then the time of purchase.

(c) x has not yet sold that thing.

In NN, the property owned-by-x-ness or tat-nirūpita-svatva *is defined as*

tat-kartṛka-kraya-viśiṣṭa-sambandha-kraya-vaiśiṣṭyam
sva-karma-pratiyogitva
evam sva-viśiṣṭya-kāla-anuyogikatva-ubhaya-sambandhena

sva-vaiṣiśtya

sva-uttaratva

evam sva-viśiṣṭa-vikraya-anuttaratva ubhaya sambandhena

sva-vaiśiṣṭya

sva-samāna-kartṛkatva

evam sva-samāna-karmakatva ubhaya sambandhena

We explain the definition with the help of diagrams.
tat-nirūpita-svatva *is the property of* karma, *where* tat *refers to* kartā.
For example, if Rāma *has purchased a cow, then*

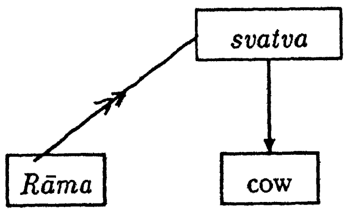


Figure 1

The first part of the definition says,
tat-kartṛka-kraya *(the purchase activity whose* kartā *is* tat*) is related to* svatva *by two relations. Those are*
a) svatva *is a property in the* karma *of the purchase activity.* svatva *resides in* karma *by* svarūpa-sambandha.

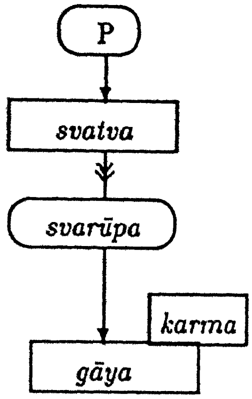
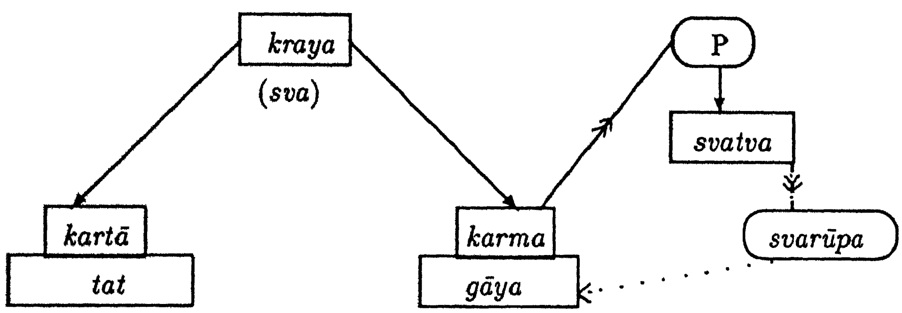


Figure 2

tat-kartṛka-kraya *is related to* svatva *by the* pratiyogitā *of the* karma *of purchase activity.*

i.e.



— (I)

Figure 3

b) naiyāyika *held the view that all the objects are related to time of reference (*kāla*) by* svarūpa sambandha.
Hence svatva *also resides in* kāla *by* svarūpa sambandha.
kāla *being the* anuyogi, anuyogi nirūpakatā *is in* svatva.

The time of reference should be related to the time of purchase activity

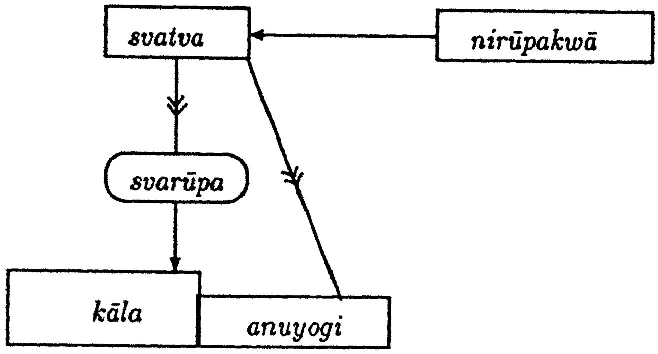


Figure 4

by some relation.

Hence

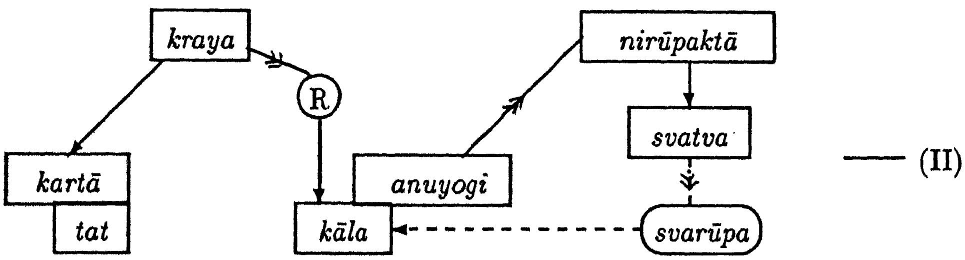


Figure 5

Combining (1) and (2), we get Figure 6. [See next page]

Further the time of reference is related to the purchase activity by special relations. These are

- sva uttaratva
  i.e., the time of referece should by greater than the time of purchase.
  and
- sva vikraya anuttaratva

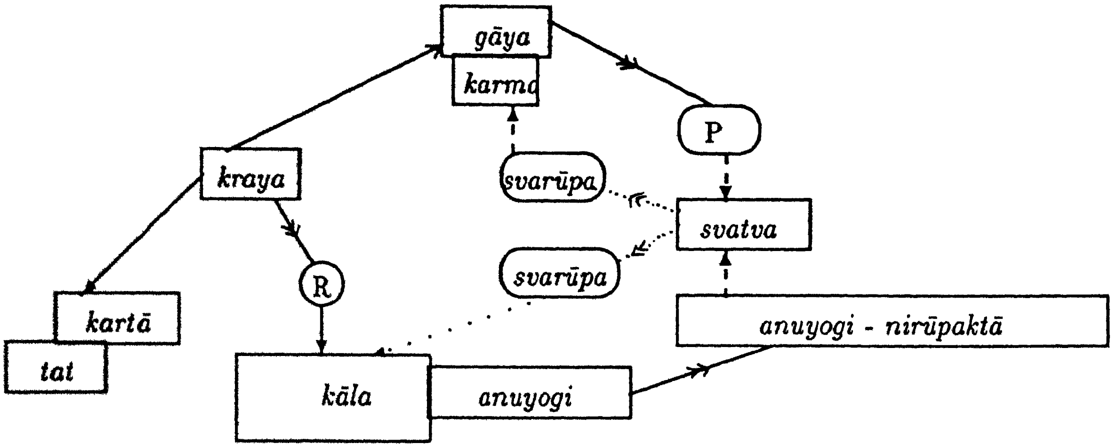


Figure 6

*i.e., the time of reference should be less than the time of selling (*vikraya*) the object.*

Hence



Figure 7

will expand as

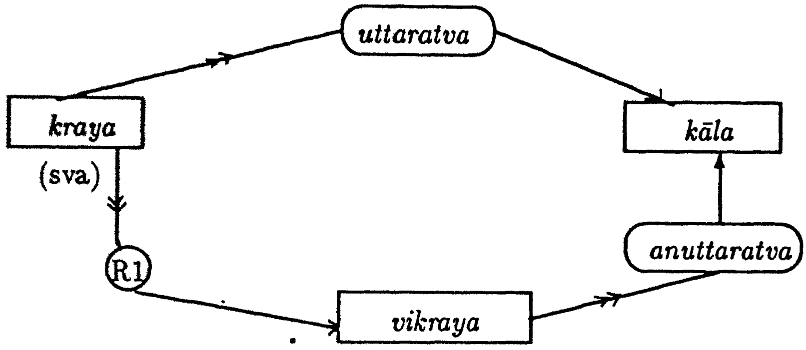


Figure 8

The selling activity is again related to the purchase activity such that the kartā *and* karma *of both the activities are same.*
Therefore,

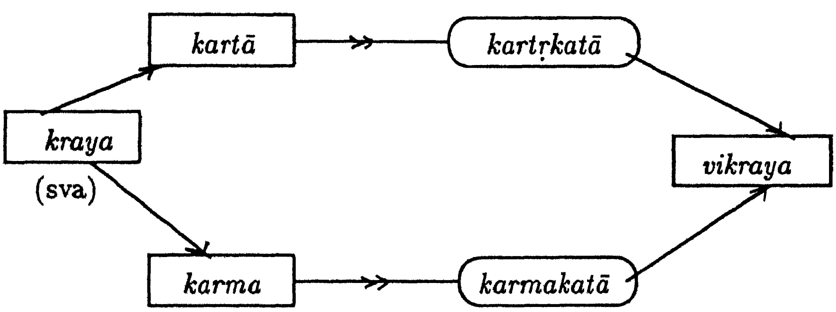


Figure 9

Replacing (R1) in Figure 8 by Figure 9 and (R) in Figure 6 by Figure 8 ,
we get

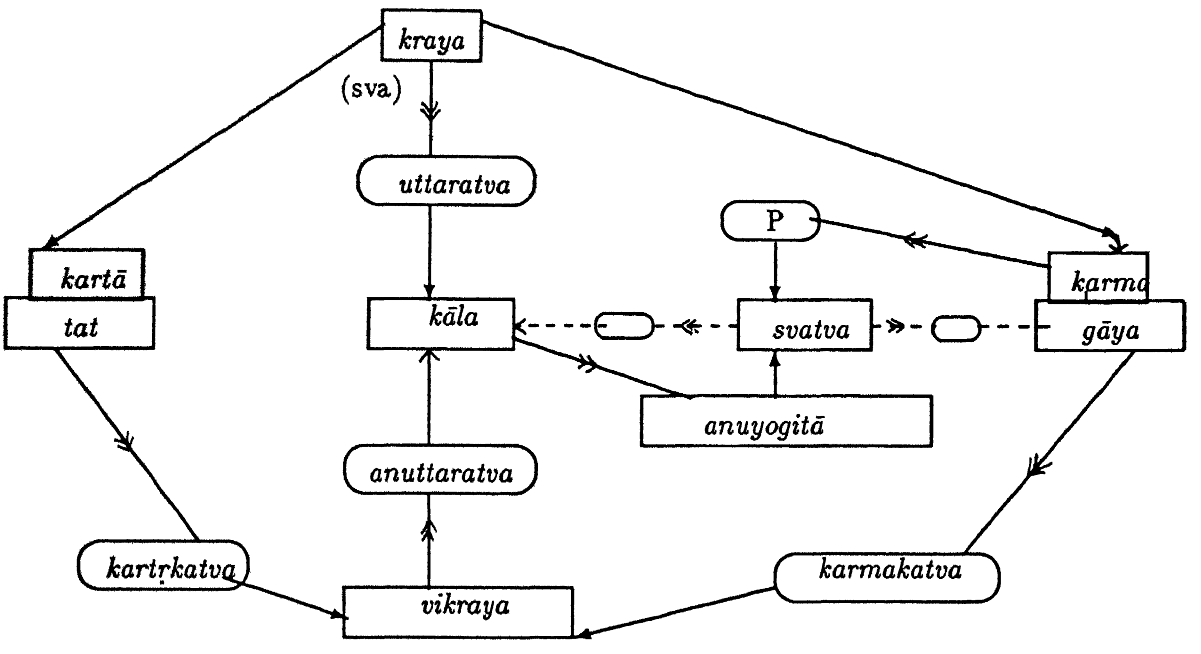

kraya
(sva)
uttaratva
P
kartā
tat
kāla
svatva
karma
gāya
anuyogitā
anuttaratva
kartṛkatva
karmakatva
vikraya

Figure 10